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An Augmented A/P/C Cohort Model: Applications

Part I: Changes in Household Demand for Wine in Japan

Part II: Estimating Impacts of the O-157 and BSE Incidents on Japanese At-Home Beef Consumption Using an Augmented Cohort Model

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Part I: Changes in Household Demand for Wine in Japan: Economic and Demographic Aspects

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Abstract

Alcohol consumption (per adult) in Japan increased by 30% between 1980 and the mid-1990s. It then declined by 10% between then and 2010. The consumption of wine, a relative newcomer to Japan's alcohol market, also grew sharply up to a point in the 1990s before falling off. Still, consumption quadrupled over the period as a whole. This study analyzes the effects of prices, income, aging, and generational change on at-home wine consumption from 1979 to 2011. Japan experienced rapid economic growth during the past handful of decades. This, in turn, led to changes in food consumption patterns with people born around the same point in history exhibiting more similar food choices than people born farther apart in time. We find that Japanese born between 1955 and 1979 exhibit the greatest demand for wine. However, "pure" period effects have had a greater impact on wine consumption than demographic changes. Also, when per-adult wine consumption was regressed against real prices and real household expenditures (a proxy for income), we obtained estimates of the price elasticity as large as −3.3. However, when accounting for demographic determinants of demand, we obtained an average price elasticity of −0.8 and negligible income elasticity.

JEL Classification: D12, C4, Q13
Keywords: Wine, Augmented Cohort Analysis, Price Elasticity, Pure Period Effects

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1. Introduction

Total alcoholic beverage consumption in Japan increased sharply from 6,814 thousand kiloliters (tkl) in 1980 to 9,324 tkl in 1990, more slowly to 10,015 tkl in 2000, and then gradually declined to 8,963 tkl in 2010 (Table 1)[1]. Japanese traditionally drank "sake", brewed mainly from rice with 12%–15% alcoholic content, along with beer and "shochu", spirits brewed from sweet potato, barley and/or rice with 25%–35% alcoholic content. Whisky and particularly wine are relatively new drinks in Japan.

Forty years ago, sake accounted for nearly half of household expenditures spent on alcoholic beverages, followed by beer (34%) and whisky (about 10%). Sake expenditures have declined consistently since 1970. Household consumption of whisky has followed suit since 1980. However, beer, shochu, and wine have followed a different trajectory, with wine and shochu showing strong, consistent growth in household expenditures (Tables 2 and 3).

Domestically produced wine accounted for a little over 30% of Japan's wine market in the 2000s, steadily declining from 70% in the early 1980s (e.g., Japan Winery Association, 2012). Imported wine has conversely risen to account for nearly 70% of total consumption. Major suppliers include France (40%–50% market share of Japan's imports in the late 2000s), Italy (20%), Chile (12%–15%), Spain (7%–10%), the U.S. (7%–9%), and Australia (6%–7%). Domestically produced wine includes wine brewed from domestically produced grapes blended with wine imported in bulk. It is estimated that "75 percent of domestically produced volumes" are produced with imported ingredients (USDA, *GAIN Report*, 2/23/2011, pp. 5–6). International interest in Japan's wine market has recently motivated research on the determinants of consumption (Arahata, 2004; Rod and Beal, 2012 among the few). Rod and Beal (2012), for one, note that Japan's wine market is subject to "fads and fashions" (p. 10). For example, in the late 1990s, consumption grew rapidly due to reports about the potential health benefits of drinking red wine. However, much work remains to be done. Still needed are accurate price and income elasticities as well as a better understanding of how consumption varies by some key demographic characteristics.

Changes in prices and income do not appear to explain all of the changes in the composition of Japan's market for alcohols. Japan's economy expanded very rapidly during the 1980s. The economic bubble then burst in the early 1990s. However, even as household income has changed relatively little since that time, trends in alcohol consumption have not stabilized. Shown in Table 2 are price trends over these same years. The figures in the parentheses of each cell in Table 2 denote

Table 1. Consumption of Alcoholic Beverages in Japan, 1980 to 2010 (1000 kl)

Year	Sake	Shochu	Beer	Whisky	Wine	Total
1980	1494	247	4533	354	47	6814
1985	1377	626	4861	273	68	7464
1990	1444	599	6586	211	132	9324
1995	1364	685	7231	148	158	10006
2000	1060	782	7162	125	269	10015
2005	795	1044	5340	84	257	9549
2010	647	970	3909	96	274	8963

Note: Quantities in terms of taxed volume.
Sources: http://www.nta.go.jp/shiraberu/senmonjoho/sake/tokei/mokuji.htm

Table 2. Household Purchases (liters/year) and Real Prices of Alcoholic Beverages, 1970-2010

Year	Sake	Shochu	Whisky	Beer	Wine
1970	22.08 (119)	2.13 (88)	1.84 (227)	29.57 (128)	0.44 (NA)
1980	18.31 (98)	2.63 (75)	3.19 (134)	46.76 (95)	0.55 (137)
1985	15.22 (100)	5.95 (80)	2.44 (154)	42.45 (111)	0.64 (143)
1990	13.47 (99)	4.90 (83)	1.88 (145)	55.39 (106)	0.86 (135)
1995	13.25 (104)	6.12 (88)	1.50 (135)	58.93 (103)	1.27 (124)
2000	10.83 (103)	7.01 (99)	1.16 (102)	60.16 (102)	2.40 (103)
2005	9.37 (100)	10.38 (100)	0.88 (100)	52.80 (100)	2.17 (100)
2010	7.91 (91)	10.70 (104)	0.88 (95)	54.14 (97)	2.17 (96)

Notes : Figures in parentheses denote individual CPI deflated by the aggregate CPI (base year = 2005).
Sources : *FIES*, various years.

Table 3. Household Expenditures Shares on Alcoholic Beverages (Percentages), 1970 to 2010

Year	Total	Sake	Shochu	Beer	Whisky	Wine
1970	100	48.7	2.8	34.0	9.6	1.0
1980	100	34.0	3.1	42.3	16.7	1.6
1985	100	28.2	7.8	46.2	12.6	1.7
1990	100	22.2	6.0	55.6	10.7	2.4
1995	100	22.2	7.1	57.9	7.2	2.5
2000	100	19.0	9.0	58.5	4.4	5.8
2005	100	16.8	15.2	52.3	2.8	5.6
2010	100	14.6	16.9	53.4	2.9	5.8

Sources : *FIES*, various years.

the consumer price index (CPI) for each individual product divided by the aggregate CPI with 2005 = 100. Real consumer prices for sake have stayed almost constant for the past 40 years and yet per-household consumption of sake has consistently shrunk. By contrast, real prices for shochu seem to have risen slightly, partly reflecting higher levels of quality, perhaps, but household consumption has quadrupled. Real consumer prices for wine have declined gradually over the past 30 years concurrent with steadily increasing consumption.

The demand for alcohols as well as many types of food varies among Japanese according to some key demographic characteristics of the individual. Japan is an aging society that has also experienced rapid economic growth and become much more internationalized over the past handful of decades. This, in turn, has led to changes in food consumption patterns with people born around the same point in history exhibiting more similar food choices than people born farther apart in time. Mori, Clason, and Lillywhite (2006), for example, investigate trends in Japanese fresh fruit consumption. Increasingly younger generations were found to consume smaller quantities of fresh apples and fresh mandarin oranges than members of older generations consume.[2] Mori and Saegusa (2010) similarly found that younger generations were inclined to consume less fish.[3] Individuals who grew up amidst post-World War II economic prosperity are likely accustomed to a more diverse diet than are members of older generations who came of age consuming these traditional foods. Both studies use an A/P/C model that decomposes consumption into the effects of an individual's age, "pure" period (time) effects, and his or her birth years (cohort). Pure time effects are the trend in consumption controlling for other variables in the model and, in the case of trends in alcohol consumption, may represent the net effects of health information like reports in the 1990s that drinking red wine is healthful, marketing efforts by companies like supermarkets that allocated increased sales space to wine, and other fads and fashions on top of the economic variables of price and income.

Two previous studies have examined the demand for alcohol in Japan allowing for the possibility that different birth cohorts exhibit different tastes and preferences. Tanaka et al. (2004) investigated sake and beer consumption using an A/P/C model. Middle-aged Japanese (i.e., those above their mid-40s) drank more than twice as much sake as those in their 20s and 30s in the survey period, 1980–2000. Sake consumption was lower among younger birth cohorts who grew up after the high economic growth of Japan's economy, which started in the early 1960s. Tanaka et al. (2004a) surmised that those in their 50s and 60s in 2010 to 2020, for example, would not drink as much sake as their counterparts did some 20–30 years ago, because they belong to newer generations who exhibit negative cohort effects in sake consumption. Providing some validation of their estimates, Tanaka et al.'s (2004) predictions of household sake consumption in 2010 coincided with actual consumption reported in the government's *Family Income and Expenditure Survey* (*FIES*) of 2010. Okamoto (2003) used an A/P/C model to identify cohort effects in household wine and whisky consumption. He did not, however, try to incorporate price and income effects in his modeling.

Drastic changes in the consumption structure of alcoholic beverages in the past 30–40 years in Japanese households need to be analyzed not only from the economic perspectives of price and income but also from the demographic perspectives of age and generations. As stated before, wine remains a relatively new and quickly growing product in Japan. We will investigate in this paper changes in households' at-home wine consumption using both economic and demographic frameworks. That is, we ask which birth cohorts most prefer wine. We also estimate pure time effects and calculate income and price elasticities.

[1] Alcoholic beverage consumption is measured as the taxed volume.

[2] Those in their 30s are estimated to eat (approximately) 2.0kg of apples (per year; per person) and 3.0kg of mandarin oranges, as compared to 8.0kg and 12.0kg, respectively by those in their 60s in 2000, for example (Mori et al., pp.208–9).

[3] Those in their 30s are estimated to consume 9.5kg of fresh fish (per year; per person), as compared to 20.0kg by those in their 60s in 2004, for example (Mori and Saegusa, p.48).

2. Data

The Japanese government's Bureau of Statistics has been conducting nationwide surveys of family expenditures and consumption of various goods and services of approximately 8,000 households across the country since the late 1940s and publishing the results in monthly and annual reports of the *FIES*. *FIES* publishes total expenditures on alcoholic beverages for at-home consumption, quantities, and average paid prices for individual beverages which include sake, shochu, beer, whisky, wine and other drinks. Starting in 1979, *FIES* has been publishing consumption data for individual commodities classified by the age group of the household head (HH), i.e., under 25, 25–29, ——, 60–64, and over 64. In order to undertake cohort analyses of alcoholic beverages, we will rely mainly on the *FIES* HH data since 1979.

Table 4. At-home Wine Consumption by Age Groups of Household Head, 1995

Household Head Age	Number of persons in Household	Wine (cc)	Shochu (cc)
under 25	2.88	842	1593
25–29	2.97	966	1860
30–34	3.45	1426	4641
35–39	3.99	1457	5018
40–44	4.19	1320	5807
45–49	3.95	1370	6246
50–54	3.56	1321	6440
55–59	3.14	1295	6564
60–64	2.85	1099	8402
65 +	2.61	1117	6470

Sources : *FIES*, 1995.

Table 4 illustrates household purchases (=consumption) of wine and shochu classified by HH age groups in 1995, the midpoint of the survey period, 1979 to 2011. The number in the second column denotes the average number of persons contained in each HH age group.

The figures in the third column denote annual purchases of wine in milliliters (cc) by HH age groups. It should be noted that these figures represent household consumption, not the consumption of individual household members.

In order to derive estimates of per capita consumption from *FIES* data, researchers at the Japanese government research institute, PRIMAFF, among other institutions, commonly divide household consumption for each age group by the size of households in that group (e.g., PRIMAFF, 2010). Suppose, as shown below with hypothetical numbers, that households headed by individuals aged 30, 45, and 55 years consumed 20, 40, and 20 units of a food or beverage and contained 3, 4, and 3 members, respectively :

$$HQ_{30}(3)=20 \quad (1)$$

$$HQ_{45}(4)=40 \quad (2)$$

$$HQ_{55}(3)=20 \quad (3)$$

where HQ_i denotes household consumption for HH i years of age and the figures in parentheses denote the number of persons contained in the specific household. Simple division provides per capita consumption by age as follows :

$$Q_{30}=20/3=6.7 \quad (4)$$

$$Q_{45}=40/4=10.0 \quad (5)$$

$$Q_{55}=20/3=6.7 \quad (6)$$

where Q_i denotes average per capita consumption by individuals of i years of age.

However, the above approach ignores the fact that one of the three family members of the household where HH is 30 years of age is likely an infant who does not eat as much foods as his/her parents and never drinks alcoholic beverages at all. In the case of the household where HH is 55 years of age, one of the three members is likely a grown-up adult in their 20s, who may normally eat or drink more than his/her parents. Therefore, dividing household consumption by 3, in equation (4) might lead to a substantial underestimation of per capita individual consumption of those in their 30 s, whereas doing so in equation (6) for a household head aged 55 may likely overestimate consumption for this age group.

A somewhat more accurate way to derive individual consumption estimates from household-level data, based on equivalence scales and using information on the age distribution of Japanese households covered by the *FIES*, would be to broadly re-write equations (1) to (3) as below[4]:

$$2Q_{30} + 1Q_{0} = 20 \quad (7)$$

$$2Q_{45} + 1Q_{17} = 40 \quad (8)$$

$$2Q_{55} + 1Q_{25} = 20. \quad (9)$$

In reference to sporadic nutrition surveys, whenever available and by common sense, it may be safe to further assume $Q_{0} = 0$, $Q_{25} = Q_{30}$, and $Q_{17} = 1.2^{*}Q_{25}$ for some chosen food such as pork. Then it follows that

Table 5. Estimated per capita Wine Consumption at Home by Age, 1979-2011 (cc/Year)

Year/Age	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75+
1979	206	202	183	225	260	253	276	328	209	250	271	266
1980	212	190	161	186	221	215	284	265	198	279	321	320
1981	215	199	162	221	256	253	271	278	185	210	225	220
1982	235	223	223	249	270	323	371	423	271	285	295	287
1983	341	335	357	400	287	321	303	254	278	256	244	228
1984	351	338	325	294	265	274	287	242	241	260	269	260
1985	237	270	322	236	225	194	208	272	358	334	318	296
1986	206	224	222	231	217	219	210	250	361	305	274	248
1987	369	402	405	318	305	250	213	313	259	271	275	262
1988	307	343	394	336	321	236	267	334	369	308	274	248
1989	418	476	568	451	426	328	230	288	268	284	287	272
1990	392	406	488	428	368	288	305	232	253	301	319	308
1991	318	345	407	380	363	322	287	302	281	287	289	275
1992	240	284	338	318	333	305	247	300	408	336	300	269
1993	348	389	447	435	366	256	194	200	255	250	240	219
1994	417	455	570	517	448	403	338	337	299	343	361	347
1995	473	526	692	695	613	535	409	395	374	416	432	411
1996	771	785	719	814	720	513	441	405	461	491	493	461
1997	700	769	928	993	941	765	730	808	635	644	643	610
1998	982	1169	1632	1720	1539	1300	859	802	1006	948	900	815
1999	545	722	1334	1623	1445	1237	879	815	1004	953	905	822
2000	876	960	1186	1356	1398	1183	820	719	796	841	844	781
2001	926	954	1101	1226	1283	1182	972	827	734	660	603	542
2002	623	657	951	1127	1133	1079	967	797	627	621	715	718
2003	1094	1108	1114	1107	1059	917	716	597	559	606	693	684
2004	678	716	970	1137	1180	1131	1016	904	791	664	544	467
2005	520	585	937	1170	1232	1164	1011	909	836	723	596	511
2006	399	456	748	981	1089	1032	858	768	752	690	600	525
2007	379	466	807	1185	1481	1343	890	679	700	646	535	440
2008	315	352	676	1020	1293	1291	1066	890	776	691	632	570
2009	525	518	717	958	1179	1210	1067	868	645	527	493	457
2010	521	537	674	928	1258	1314	1155	1078	1046	866	605	459
2011	513	505	789	1074	1303	1421	1419	1289	1053	895	813	747

Sources: Derived from *FIES* classified by HH age groups, by the authors.

$Q_{30} = 20/2 = 10$ (10)

which compares with 6.7 from (4),

$Q_{45} = (40 - 2*1.2*10.0)/2 = 8.0$ (11)

which compares with 10.0 from (5), and

$Q_{55} = (20 - 10)/2 = 5.0$ (12)

which compares with 6.7 from (6).

Kawaguchi (1996), who criticized this approach as too rigid, developed a more robust method, in which equations (7) through (9) and all identifying constraints, such as $Q_{25} = Q_{30}$ contain errors, or residuals, the squared sum of which can be minimized to determine the solution. Estimates of individual consumption by age in our hypothetical example derived by Kawaguchi's (1996) method are $Q_{55} = 5.07$, $Q_{45} = 8.24$, $Q_{30} = 9.94$, $Q_{25} = 9.86$, $Q_{17} = 11.78$, and $Q_0 = 0.06$. One of the advantages of this approach over simple division methods includes estimates of individual consumption by family members other than household heads and their spouses, i.e., their children and any parents who live with them. Mori and Inaba (1997) used Kawaguchi's suggestion to estimate individual consumption of fresh fruit in Japan from 1979 to 1994. Tanaka, Mori, and Inaba (2004) statistically refined this model to derive individual consumption by age from *FIES* data classified by HH age groups.

Using *FIES* data from 1979 to 2011, our estimates of per capita individual consumption of wine by age, under 25, 25–29, ――, 70–74, and 75+, are presented in Table 5. On the tacit assumption that minors do not drink alcoholic beverages, consumption of wine by minors is set a priori at zero for the entire period. When viewing the table horizontally along the age axis, one may notice apparent bulges in the 4th to 7th columns, corresponding to one's thirties and forties, especially during the period 1998 to 2005. When viewed vertically along the time axis, individual consumption increased drastically from some 200 cc in the early 1980s to between 1000 and 1300 cc toward 2000 and has slightly declined since then for age groups younger than the mid-40s. By contrast, among older age groups, especially those above 50 years old, individual consumption seems to have kept rising toward the end of the survey period. Overall, it is quite obvious that individual consumption increased dramatically up to 2000 across the board, but changes are not consistent by age groups since then. In the subsequent section, we will decompose the data in Table 5 into age, cohort and period effects.

[4] Selected issues of *FIES* and *National Survey of Family Income and Expenditure* carry statistical tables that show the ages of household members for HH age groups.

3. Identifying "Pure" Period Effects in At-home Wine Consumption, with Age and Generational Factors Accounted for

In the ordinary A/P/C model, per capita average consumption of a chosen commodity by individuals of i years of age at time t, μ_{it}, is expressed as follows :

$$\mu_{it} = B + A_i + P_t + C_k + e_{it} \quad (13)$$

where B is the grand mean effect, A_i is the age effect attributable to age i years old, P_t is the period effect attributable to time t, C_k is the cohort effect attributable to (birth) cohort k, and e_{it} is a random error. This model (equation 13) can be written in the conventional matrix form of a least-square regression:

$$Y = Xb + \varepsilon \quad (14)$$

However, when it comes to estimating the parameters of equation (13), we are confronted with a statistical difficulty, the "identification problem" (Mason and Fienberg, 1985). That is, given any two of the three elements, the third one is automatically determined. The indices of these three elements, i years old for age, survey year t, and birth years k are interdependent: $t=i+k$. For example, if we know that a person was thirty years old ($i=30$) when participating in a survey in 2000 ($t=2000$), then he or she must have been born in $k=1970$. Researchers interested in cohort effects have developed a variety of methods for identifying the model. One approach is to impose equality constraints, such as $A_i=A_j$, i.e., age effect of 45–49 years old is equal to that of 50–54 years old, for example, have been conventionally imposed. See, for example, Deaton (1997, Chapter 2.7) and Yang et al. (2004). Nakamura (1986) developed the "intuitively more natural" assumption of "gradual changes between successive parameters" which covers the entire ranges of all three elements of age, period, and birth cohorts, in lieu of any single equality constraint arbitrarily chosen. Sasaki and Suzuki (1987) and Mori, Clason, and Lillywhite (2006) provide a detailed description of Nakamura's Bayesian methodology for estimating A/P/C effects. We do not repeat that description in the present paper.

To first prepare the data in Table 5 for decomposition into age, period, and time effects, we delete the oldest age group, 75+, because this age cell contains more than one birth cohort. For example, the age cell, 70–74 years of age in 1979, contains one single cohort, born in 1905–09, whereas the oldest cell of 75+ in the same year contains cohorts born in 1900–1904, 1895–1899, and even older cohorts born prior to 1895. We also delete the youngest age cell, under 25 years of age, because per capita individual consumption derived for this group can be quite unstable given the small sample sizes for HH age group under 25 in *FIES*, e.g., 50 out of a total of 7,987 tabulated in 1985 and 46 out of 7,901 tabulated in 1999, respectively.

Estimation results from applying Nakamura's method to the data in Table 5 are provided in Table 6 for 10 age groups from 25–29 to 70–74 years old and 33 annual years from 1979 to 2011. The period effects given in the middle column demonstrates "pure" time effects for 1979 to 2011, accounting for age and cohort effects in household wine consumption.

Japanese born from 1955 to 1979, who came of age during the period of post-war prosperity, exhibit a greater demand for wine, all else constant. Cohort effects for this segment of the population are distinctly positive as was expected from a quick visual inspection of Table 5. However, as compared with consumption trends for other products such as fish and fresh fruits, the demographic effects of age and generation are not as dominant a factor in determining trends in individual wine consumption (e.g., Mori and Saegusa, 2010; Mori, Clason, and Lillywhite, 2006; Mori and Stewart, 2011).

The period effects derived from the A/P/C cohort model, or "pure" time effects controlling for aging and generational replacement, seem to match very closely trends in simple average household wine consumption per adult over the survey period of 1979 to 2011, as demonstrated by Figure 1.[5] The estimated time effects are increasing from year-to-year over much of the mid-1990s, then dropping abruptly to 2001–02 and relatively flat after that. Notably, it is not always the case that pure time effects estimated from an A/P/C model correspond closely to observed trends. Average per capita household consumption of fresh fruit, for example, persistently declined from 39.3kg in 1980 to 31.7 and 27.7kg in 1995 and 2010, respectively. It is widely accepted that the younger generations of Japanese populace have moved away from eating fresh fruit (e.g., Ministry of Agriculture, For-

Table 6. Individual Wine Consumption Decomposed by Age, Period, and Cohort Effects : Bayesian Estimator Model

Grand Mean Effect = 597.1 (9.912) (in ml)

Age Effects (A_i) (age group)		(SD)	Period Effects (P_t) (year)		(SD)	Cohort Effects (C_k) (born in)		(SD)
25–29	−204.7	(78.5)	1979	−281.8	(60.7)	1905–09	15.5	(154.8)
30–34	−86.2	(62.4)	1980	−295.2	(57.6)	1910–14	−5.3	(127.3)
35–39	17.5	(45.7)	1981	−299.0	(54.7)	1915–19	−38.5	(109.3)
40–44	90.7	(29.6)	1982	−245.1	(51.6)	1920–24	−54.8	(91.5)
45–49	97.5	(16.5)	1983	−238.6	(48.6)	1925–29	−46.9	(74.1)
50–54	54.6	(16.5)	1984	−264.1	(45.7)	1930–34	−97.5	(57.2)
55–59	46.4	(29.6)	1985	−276.6	(42.8)	1935–39	−154.6	(41.0)
60–64	32.2	(45.7)	1986	−298.7	(40.1)	1940–44	−172.1	(27.0)
65–69	−1.5	(62.4)	1987	−262.5	(37.4)	1945–49	−144.0	(20.5)
70–74	−46.5	(314.5)	1988	−249.4	(34.9)	1950–54	−56.8	(26.4)
			1989	−219.7	(32.6)	1955–59	95.1	(39.5)
			1990	−244.1	(30.5)	1960–64	244.3	(55.7)
			1991	−263.8	(28.7)	1965–69	319.8	(72.5)
			1992	−279.9	(27.1)	1970–74	277.3	(89.7)
			1993	−292.4	(26.0)	1975–79	115.4	(107.1)
			1994	−202.9	(25.3)	1980–84	−86.8	(125.2)
			1995	−109.4	(25.0)	1985〜	−210.4	(143.0)
			1996	−29.8	(25.3)			
			1997	170.8	(26.0)			
			1998	524.1	(27.1)			
			1999	457.2	(28.6)			
			2000	375.3	(30.5)			
			2001	312.9	(32.6)			
			2002	232.2	(34.9)			
			2003	212.7	(37.4)			
			2004	261.4	(40.1)			
			2005	267.4	(42.9)			
			2006	169.0	(45.7)			
			2007	228.6	(48.6)			
			2008	227.4	(51.5)			
			2009	192.6	(54.6)			
			2010	308.7	(57.6)			
			2011	412.6	(60.9)			

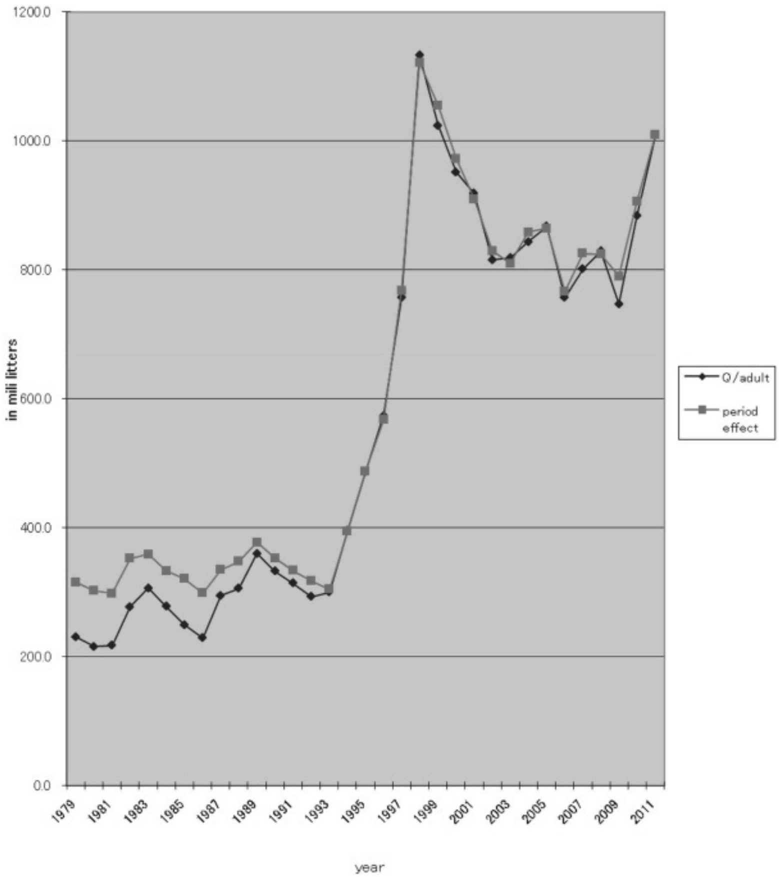
Notes : $\Sigma A_i = \Sigma P_t = \Sigma C_k = 0$; Figures in parentheses denote SD.

estry, and Fisheries, 1995 ; Mori et al., 2009 ; Mori and Stewart, 2011). However, research has shown that the "pure" period effects associated with fresh fruit consumption rose slightly from 30.6 kg to 34.2kg over the corresponding period, controlling for the effects of aging and generational replacement (e.g., Mori, Saegusa, and Dyck, 2012).

Estimation of an A/P/C model not only tests a potential explanation for trends in consumption, i.e., generational differences in tastes and preferences, but research suggests that failure to account for cohort effects in a demand model can bias estimates of price and income elasticities (e.g., Mori, Clason, and Lillywhite, 2006). Below, we consider this possibility for the case of Japanese wine demand. Specifically, we first estimate price and income elasticities using simple cross-sectional and time series models that ignore cohort effects. We then augment our A/P/C model with price and income variables.

[5] This may not necessarily imply that it should hold true for the future.

Fig. 1 Comparison of Simple per capita and Period Effects: The Case of at-home Wine Consumption, 1979-2011



4. Determining Demand Elasticities for At-home Wine Consumption

FIES furnishes data on household purchases of various goods and services, including wine. The data are disaggregated by the annual income level of the households. The 1979 annual report was the last report to publish data for 18 income classes whereas the most recent annual reports only present data classified by income quintile. One can obtain, however, more detailed data for 15–18 annual income classes via CD-Roms at a library attached to the Bureau of Statistics. Below, in equations (15) to (17), we report estimates of income elasticities for household wine consumption obtained by estimating double-log, cross-sectional regression equations using *FIES* data for three years, 1985, 1990, and 1995, respectively. In running the regressions, the top 1 and bottom 2 or 3 income classes were deleted for each year to avoid possible outliers.

First, using *FIES* data from only the year 1985, we find that:

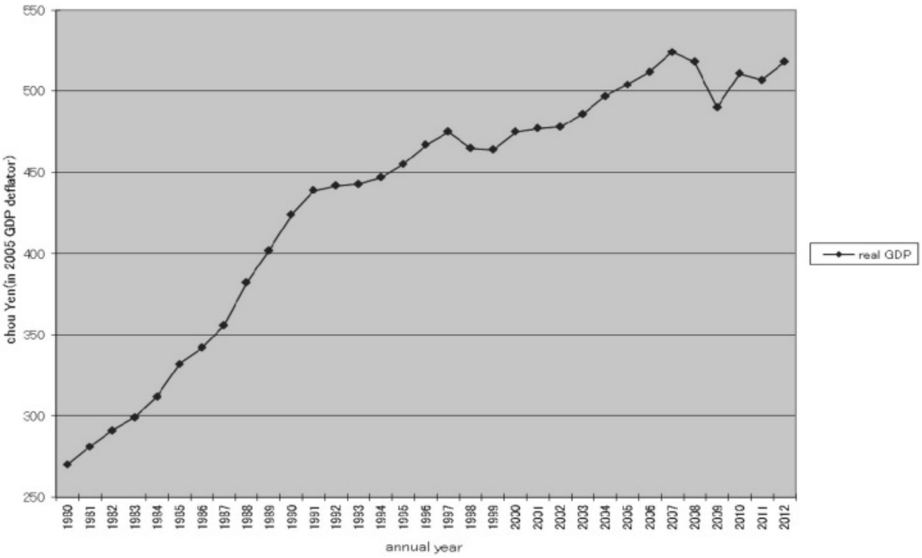
$$\log(HQ_i) = a + b \log Y_i + e_i \qquad (15)$$

$$= 5.21 + 0.75 \log Y_i$$

$$(23.6) \quad (5.4) \qquad \text{adj } R^2 = 0.68$$

where HQ_i is average household wine consumption in milliliters for the i^{th} household income class,

Fig. 2 Changes in Real GDP, 1980-2012



Y_i is average household annual income for that class in millions of yen, and e_i is a random error. The figures in parentheses denote t-values.

Similarly, using *FIES* data from 1990, we obtain :

$$\log (HQ_i) = a + b \log Y_i + e_i \quad (16)$$
$$= 5.42 + 0.74 \log Y_i$$
$$(23.7) \ (5.5) \qquad \text{adj } R^2 = 0.69$$

Lastly, using *FIES* data for the year 1995, we find that :

$$\log (HQ_i) = a + b \log Y_i + e_i \quad (17)$$
$$= 5.89 + 0.63 \log Y_i$$
$$(34.8) \ (6.6) \qquad \text{adj } R^2 = 0.77$$

Based on the above results, it may appear safe to conclude that wine in present day Japan is a normal good, consumption of which tends to increase with income. Japan's economy expanded very rapidly ("bubbly") during the 1980s. However, the bubble burst in the early 1990s and the economy has subsequently experienced the "lost 20 years" (Figure 2). It is therefore curious that per-adult household wine consumption increased only moderately from 1979 to 1993, surged dramatically up to 1998, dropped abruptly up to 2002, and then stagnated, as is clearly demonstrated by Figure 1 above.[6] How can we then explain these dramatic changes in household wine consumption? Income should be an important factor but changes in consumption have not seemed to follow changes in national income very closely for the past three decades.

The next exercise in our analysis involved analyzing changes in household wine consumption and changes in prices using traditional time series techniques. As shown below, the first time series model we estimated was :

$$\log Q_t = a + b \log P_t + e_t \quad (18)$$

$$= 22.56 - 3.35 \log P_t$$

(13.5) (9.79) adj $R^2 = 0.75$

where Q_t is per adult household wine consumption in year t in milliliters, P_t is the average real paid price for wine in year t (2005 yen/100ml), and e_t is a random error. Figures in parentheses denote t values. The second, third, and fourth time series models we estimated were :

$$\log Q_t = a + b \log P_t + c \log EXP_t + e_t \quad (19)$$

$$18.57 - 3.26 \log P_t + 0.70 \log EXP_t \qquad \text{adj. } R^2 = 0.74$$

(2.71) (8.60) (0.60)

$$\log Q_t = a + b \log P_t + c \log EXP_t + dT + e_t \quad (20)$$

$$27.38 - 0.57 \log P_t - 4.02 \log EXP_t + 0.089T \qquad \text{adj. } R^2 = 0.92$$

(6.79) (1.44) (0.88) (8.02)

$$\log Q_t = a + b \log P_t + dT + e_t \quad (21)$$

$$12.72 - 1.52 \log P_t + 0.034T \qquad \text{adj. } R^2 = 0.86$$

(5.54) (3.45) (5.09)

where, additionally, EXP_t is household expenditure per adult equivalence scale in year t in millions of 2005 yen and T accounts for a time trend, starting from 10 in 1979 incremented by 1 each year.

By these statistical results, average household expenditures as proxies for income have not influenced household wine consumption over the period from 1979 to 2011 to much extent. Average household consumption has instead been determined significantly by the prices that households faced and actually paid. The question then arises as to what degree? Average price elasticities of −3.35 and −3.26 from models (18) and (19) seem intuitively too large.[7] Estimates of −0.57 from model (20) and −1.52 from model (21) appear to be more reasonable in reference to international comparisons (e.g., Wang et al., 1996, Tables 2 and 4, p. 484 and p. 487 ; Arahata, 2004, pp. 23–24 ; Fogarty, 2010, Table 2, pp. 438–448 and Table 3, p. 452) and also by the authors' common sense. The addition of the time trend, T, in models (20) and (21) also improves statistical performance significantly. The problem is that we have neither a theoretical nor empirical justification for introducing a linear time trend into our time-series demand models for wine over the period in question.

In contrast to the simple cross-sectional and time series models estimated above, several studies have incorporated income and price variables into A/P/C models. Stewart and Blisard (2008), for one, did so in their recent investigation of fresh vegetable consumption in the United States (2008, pp. 47–48). Following the lead of their study, the Japanese government research institute, PRIMAFF, introduced price and income variables into their forecast of future food expenditures in rapidly aging Japan (PRIMAFF, 2010 ; Yakushiji, 2010). In the spirit of these studies, we will also try to augment our Bayesian cohort model with economic variables to determine price and income elasticities of demand for household wine consumption in Japan.

When price is added to our A/P/C model for wine consumption, the average price elasticity (standard error in parentheses) is found to be −0.794 (0.421), with an accompanying AIC of −236.4 and, when the income variable is further added, average price and income elasticities are estimated at −0.798 (0.427) and −0.001 (0.006), respectively with AIC at −235.7.[8] For the analysis in Table 6 which decomposes changes in wine consumption into age, period and cohort effects with no eco-

Table 7. Individual Wine Consumption Decomposed by Age, Period, and Cohort Effects, with Price added to the Model : Bayesian Estimator Model

Grand Mean Effect = 10.085 (2.057) ; Average Price Elasticity = − .794 (.421) (in natural log)

Age Effects (A_i) (age group)		(SD)	Period Effects (P_t) (year)		(SD)	Cohort Effects (C_k) (born in)		(SD)
25–29	−.234	(.073)	1979	−.514	(.073)	1905–09	.105	(.102)
30–34	−.087	(.071)	1980	−.553	(.100)	1910–14	.036	(.102)
35–39	.018	(.068)	1981	−.554	(.087)	1915–19	−.064	(.105)
40–44	.092	(.062)	1982	−.367	(.095)	1920–24	−.121	(.111)
45–49	.086	(.055)	1983	−.364	(.094)	1925–29	−.036	(.119)
50–54	.046	(.055)	1984	−.408	(.097)	1930–34	−.111	(.129)
55–59	.061	(.062)	1985	−.494	(.097)	1935–39	−.224	(.128)
60–64	.044	(.068)	1986	−.508	(.082)	1940–44	−.240	(.122)
65–69	.018	(.071)	1987	−.361	(.077)	1945–49	−.174	(.120)
70–74	−.044	(.073)	1988	−.255	(.083)	1950–54	−.052	(.124)
			1989	−.195	(.073)	1955–59	.154	(.125)
			1990	−.252	(.073)	1960–64	.329	(.137)
			1991	−.300	(.077)	1965–69	.371	(.121)
			1994	−.378	(.077)	1970–74	.331	(.114)
			1995	−.448	(.091)	1975–79	.167	(.106)
			1994	−.282	(.089)	1980–84	−.148	(.108)
			1995	−.203	(.086)	1985～	−.322	(.117)
			1996	−.058	(.072)			
			1997	.263	(.069)			
			1998	.641	(.075)			
			1999	.618	(.067)			
			2000	.525	(.059)			
			2001	.483	(.061)			
			2002	.394	(.057)			
			2003	.398	(.058)			
			2004	.459	(.056)			
			2005	.432	(.056)			
			2006	.333	(.064)			
			2007	.361	(.062)			
			2008	.314	(.074)			
			2009	.333	(.079)			
			2010	.438	(.117)			
			2011	.493	(.162)			

Notes : $\Sigma A_i = \Sigma P_t = \Sigma C_k = 0$; Figures in parentheses denote SD.

nomic variables, AIC is calculated at −230.8, substantially larger than the above two cases. On the one hand, it may be statistically safe to conclude that changes in household expenditures as a proxy for income have not been a significant factor in determining trends in household wine consumption over the period of 1979 to 2011. On the other hand, we are inclined to believe that own price changes have been the dominant economic factor, with an average elasticity in the neighborhood of −0.8. We also have to admit that it is desirable to add the economic variables, at least price, to our earlier cohort analysis. The results of our augmented cohort analysis are provided in Table 7, in which all parameters are estimated in natural logs. In order to compare these results with our estimates of the parameters for the traditional A/P/C model without the economic variables, we again decompose the data in Table 5, in natural logs this time and provide the results in Table 8, which is therefore a log-version of Table 6.

Finally, we provide in Figure 3 a visual comparison of pure period effects in household wine consumption from 1979 to 2011, derived by Bayesian cohort models with and without the price variable

Table 8. Individual Wine Consumption Decomposed by Age, Period, and Cohort Effects : Bayesian Estimator Model

Grand Mean Effect = 6.211 (.015) (in natural log)

Age Effects (A_i) (age group)		(SD)	Period Effects (P_t) (year)		(SD)	Cohort Effects (C_k) (born in)		(SD)
25–29	−.239	(.073)	1979	−.637	(.056)	1905–09	.095	(.102)
30–34	−.091	(.071)	1980	−.694	(.055)	1910–14	.027	(.102)
35–39	.015	(.068)	1981	−.696	(.055)	1915–19	−.072	(.105)
40–44	.090	(.062)	1982	−.487	(.055)	1920–24	−.127	(.112)
45–49	.086	(.056)	1983	−.445	(.055)	1925–29	−.041	(.119)
50–54	.046	(.056)	1984	−.514	(.055)	1930–34	−.115	(.130)
55–59	.063	(.062)	1985	−.559	(.056)	1935–39	−.226	(.128)
60–64	.047	(.068)	1986	−.623	(.056)	1940–44	−.241	(.122)
65–69	.022	(.071)	1987	−.483	(.056)	1945–49	−.175	(.120)
70–74	−.039	(.073)	1988	−.420	(.057)	1950–54	−.051	(.124)
			1989	−.347	(.058)	1955–59	.156	(.126)
			1990	−.390	(.058)	1960–64	.333	(.137)
			1991	−.421	(.059)	1965–69	.376	(.121)
			1992	−.460	(.061)	1970–74	.337	(.114)
			1993	−.516	(.063)	1975–79	.174	(.106)
			1996	−.246	(.064)	1980–84	−.139	(.108)
			1997	−.037	(.065)	1985～	−.311	(.117)
			1996	.108	(.064)			
			1997	.407	(.062)			
			1998	.749	(.061)			
			1999	.701	(.059)			
			2000	.628	(.058)			
			2001	.560	(.058)			
			2002	.477	(.057)			
			2003	.448	(.056)			
			2004	.507	(.056)			
			2005	.511	(.056)			
			2006	.401	(.055)			
			2007	.436	(.055)			
			2008	.438	(.055)			
			2009	.410	(.055)			
			2010	.548	(.055)			
			2011	.651	(.056)			

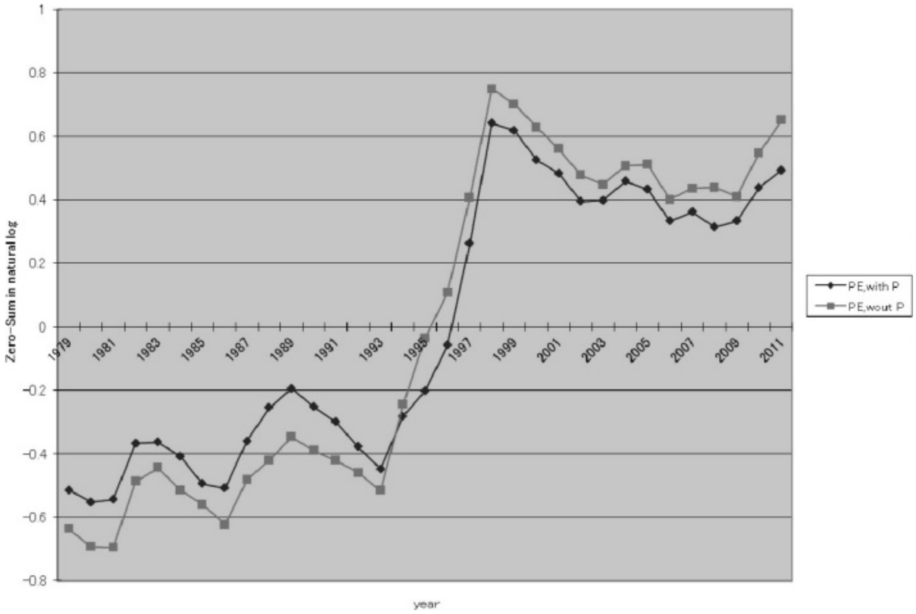
Notes : $\Sigma A_i = \Sigma P_t = \Sigma C_k = 0$; Figures in parentheses denote SD.

over the period in question. When the price variable is added to the model, the pure period effects proved slightly narrower in width than the original model but the basic periodical pattern in wine consumption as observed in Figure 2 does not change much. As discussed above, this likely represents the net effects of information like reports in the 1990s that drinking red wine is healthful, increased sales space provided for wine by ordinary supermarkets, and other "fads and fashions". Greater precision would require further research conducted from marketing perspectives.

[6] Per adult wine consumption in terms of taxed volume more than doubled from 658ml in 1980 to 1,450ml in 1990 and kept increasing to 2,660ml in 2000 and stagnated since then to 2,600ml in 2010. At-home consumption is estimated to account for 37.1% of total wine consumption in 1980 and this share gradually dropped to 22.9% in 1990 but recovered to 35.8% in 2000 and remained at this level since then (the Japanese government National Tax Agency, 2012).

[7] When simple per adult consumption, Q_t , in model (19) above was replaced by the period effects, P_t from model (13) in the preceding section, the average price and income elasticity are estimated at −2.98 (8.58) and 0.18 (0.17), respectively, with adj. $R^2 = 0.73$, as can be inferred from Figure 1.

Fig. 3 Comparison of Period Effects in Wine Consumption, Deriverd with and without Price, 1979-2011



[8] Akaike's Information Criteria (H. Akaike, 1980).

5. Summary and Discussions

In Japan, alcohol consumption per adult increased steadily from 1980 to the early 1990s by a little over 20% and then began to decline gradually to the 1980 level in 2010. That of sake, a traditional Japanese drink made from rice has declined persistently over the 30-year period by more than 60% to one third of the level of the early 1980s. That of beer sharply increased by more than 30% to the early 1990s and then began to decline considerably to two thirds of the level of the early 1980s in 2010. That of whisky followed a pattern similar to that of sake, whereas that of shochu rose consistently by 200% to 2010. At the same time, consumption of wine per adult more than tripled over the same period.

The price of sake (defined in terms of a real CPI deflated by an aggregate CPI) remained the same, whereas that of shochu rose steadily by some 20%–30% and that of beer remained more or less the same over the period of 1980 to 2010. That of whisky fell considerably in the neighborhood of 30% and the price of wine followed the same pattern as whisky over the same period.

It was found by Tanaka et al., 2004 that newer generations exhibit increasingly negative cohort effects when it comes to sake consumption and older people above fifty years of age carry increasingly negative age effects in beer consumption. Changes in sake and beer consumption in the past three decades can largely be attributed to changes in population demographics, i.e., aging in a narrow sense combined with the replacement of older generations by the new. What about the case of wine, which has greatly increased in consumption over the corresponding period? Our cohort analysis of household wine consumption has revealed that Japanese born from 1955 to 1979, who came of age during the period of post-war prosperity, exhibit the greatest demand for wine for at-home consumption, all else constant. However, “pure time effects” have been predominant in steadily increasing wine consumption in the past three decades.

Failure to account for cohort effects, when present can bias estimates of price and income elasticities. In simple analyses of cross-sectional data that did not account for this possibility, wine consumption was found to be very sensitive to changes in income, with an average income elasticity estimated in the neighborhood of 0.7, using data of 8,000 households classified by some 15 income classes in 1985, 1990, and 1995, respectively. Ordinary time-series analyses of per-adult wine consumption from 1979 to 2011, however, did not support these findings. Japan’s national economy expanded remarkably from the end of 1970s to the early 1990s when the bubble burst and has been stagnated for the subsequent 20 years. Household wine consumption increased only moderately during the 1980s and began to surge in 1993 to the peak years of 1998–99. It then fell abruptly by 20%–30% to the early 2000s and stagnated to 2010.

The incorporation of income and price variables into an A/P/C model reveals which birth cohorts most prefer wine, i.e., Japanese born from 1955 to 1979. We also obtain reasonable income and price elasticities. The remaining “pure” period effects are hypothesized to reflect the effects of information about the healthfulness of wine consumption, the marketing efforts of various agencies concerned including supermarkets, and other temporal phenomena. Given the basis provided in this paper for modeling wine demand in Japan, the authors encourage further research be conducted particularly from a marketing perspective to better dissect these period effects.

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Part II: Estimating Impacts of the O-157 and BSE Incidents on Japanese At-Home Beef Consumption Using an Augmented Cohort Model

Hiroshi Mori

Abstract

Per capita at-home beef consumption increased steadily by 50% from the early 1980s to the mid-1990s, despite a drastic rise in away from home beef consumption. Beef consumption ceased to grow in the mid-1990s, began to decline appreciably in the early 2000s and, in the early 2010s, remains substantially below the mid-1990 level. These changes in beef consumption may have been caused by the booming economy during the 1980s, the steady fall in beef prices due to gradual trade liberalization in the early 1990s, changes in population structure, and last but not the least the incidents of *E. coli* O-157 in 1996 and BSE in 2001. This paper attempts to estimate the likely impacts of these incidents on at-home beef consumption in the framework of economic and demographic change, using the A/P/C cohort model augmented with economic variables.

Results confirm the importance of the disease events and relative price changes for beef consumption in Japan.

JEL : D12, D03, Q13

Keywords : beef, O-157, BSE, A/P/C effects, price elasticity, income elasticity

1. Introduction

Beef consumption in Japan increased steadily from the early 1980s to the mid-1990s, due to the gradual deregulations of beef trade and the booming national economy during the 1980s. During this period, per capita consumption increased from 3.5 kg to 7.5 kg according to the *Food Balance Sheet* (*FBS*) and per capita at-home consumption also rose from 2.4 kg to 3.6 kg according to the *Family Income and Expenditure Survey* (*FIES*). As is shown in Fig. 1, beef consumption ceased to grow in the mid-1990s and began to drop appreciably in the early 2000s.

E. coli O-157 was detected in selected leafy vegetables and some beef cuts in the middle of 1996 and is suspected to have adversely affected beef consumption (Oniki, 2006 ; etc.). Much more seriously, BSE was discovered in some beef cattle in the fall of 2001 and severely damaged the beef market across the country (Watanabe, 2004 ; Hanawa Peterson, 2005 ; alic, *beef statistics* ; etc.). Imports of grain-fed beef from North America were suspended, starting in the beginning of 2004, due to the discovery of BSE infections in cattle in the U.S. During the 10 year period since 2001, beef consumption either by *FBS* or *FIES* measures has not recovered to the mid-1990 level, approximately 20% below or 35% below, respectively, in 2011.

Japan's population has been rapidly aging during the past decades. Of approximately 8,000 households (not including single person households) covered by the *FIES*, those headed by under 40 year-olds and by 60 year-olds and over, respectively, accounted for 37.6 and 14.4% in 1980, 22.3 and

Fig. 1 Changes in Beef Consumption, 1980-2010

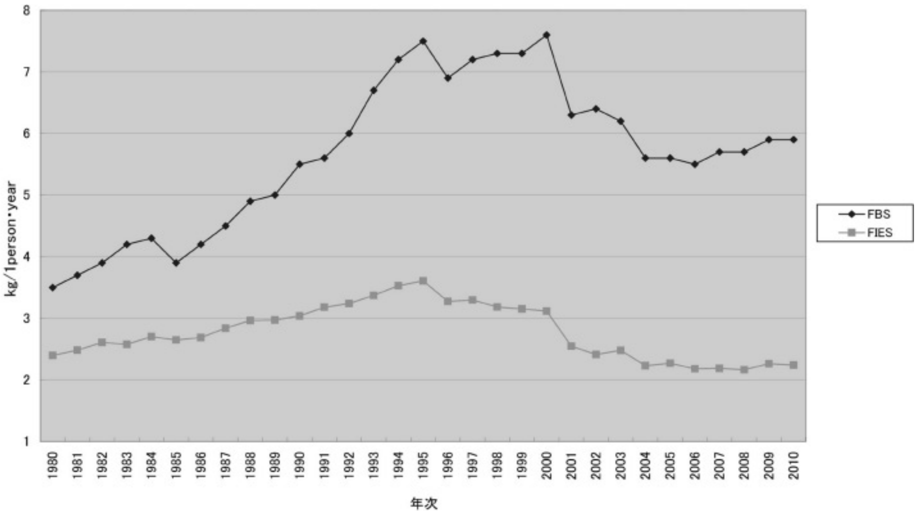


Table 1. Percentages of Meat Consumption by Major Outlets, 1975-2010 (%)

year		1975	1980	1985	1990	1995	1996	2000	2001	2002	2003	2008	2010
Beef	At-Home	70	62	56	48	43	41	37	33	34	34	34	34
	Processing	13	14	14	9	8	9	9	10	7(8)	9	6	5
	Other*	17	24	30	43	49	50	54	57	59(58)	57	60	61
Pork	At-Home	59	52	46	40	40	40	41	42	42	40	45	46
	Processing	19	25	27	30	31	31	28	26	24(30)	29	25	25
	Other	22	23	27	30	29	29	31	32	34(28)	31	30	29
Chicken	At-Home	52	46	40	32	30	30	31	31	33	32	37	38
	Processing	3	4	7	8	11	11	9	9	11(12)	10	8	7
	Other	45	50	53	60	59	59	60	60	56(55)	58	55	55

Sources : Meat and Eggs Division, MAFF.
* : Institutional and Eating Out.

27.8% in 1995 and 16.4 and 45.2%, in 2010. Beef is known to vary in individual consumption by age (Ishibashi, 2006 ; Saegusa and Mori, 2012). As is shown by Table 1, household consumption accounted for nearly 70% of total beef distribution in the late 1970s but the ratio of at-home consumption has been steadily declining to 37% in 2000 and to 34% by 2010. It has become increasingly common for Japanese consumers to eat beef outside the home : e.g., gyu-don (beef bowls), hamburgers for lunch and Korean yakiniku for informal dinner since the 1970-80s. By casual observations, men favor gyu-don appreciably more than women and the young, and the younger generations patronize hamburger restaurants far more than the old in Japan. Regrettably, no objective data exist to substantiate these phenomena.

We will try to identify the impacts of the O-157 and BSE incidents on at-home beef consumption in Japan in the framework of demographic and economic analyses, i.e., accounting for the effects of aging and generational changes of population on the one hand and the economic factors of price and income changes on the other during the period of 1980 to 2011. The data used mainly depends on *Family Income and Expenditure Survey* by the Japanese government's Bureau of Statistics, which classify household consumption by age groups of household-heads (HH). The model applied is the cohort analysis augmented with price and household income, designed by Saegusa (Saegusa and Mori, 2012), following the lead of Stewart and Blisard (2008, pp. 47–8).

2. Individual Beef Consumption by Age, 1980–2011 Decomposed into Age, Period and Cohort Effects by a Traditional A/P/C Model

Individual (at-home) beef consumption by age was derived from *FIES* HH data from 1980 to 2011, using the Tanaka, Mori and Inaba model (2004) and is provided in Table 2. Age, period and (birth) cohort effects estimated by the Nakamura's Bayesian estimator (Nakamura, 1986) are shown in Table 3 (in actual number of 100g) and Table 4 (in natural log), with each effect constrained to "sum to zero", respectively. The model (1) is an ordinary additive A/P/C equation.

$$\mu_{it} = B + A_i + J_t + C_k + e_{it} \quad (1)$$

where

μ_{it} : average individual consumption by those of i years of age in the year, t

B : grand mean effect

A_i : age effect to be attributed to age i years old

J_t : period effect to be attributed to year t

C_k : cohort effect to be attributed to birth cohort k

e_{it} : random error

Model (1) can be written in the conventional matrix form of a least-square regression :

$$Y = Xb + \varepsilon \quad (2)$$

As evident in Table 2 and Table 3, those in their middle age (40s and 50s) carry positive age effects, distinctly larger than the average of zero ; age effects become gradually smaller among the older ages ; and, surprisingly, those in their 20s and 30s show a negative age effect. The older cohorts born before the mid-1930s, who came of age during the food shortage era, when per capita meat supply was less than 2–3 kg per year on average, have a negative cohort effect ; those born during the 1940–1970 period have a clearly positive cohort effect ; but those newer cohorts born after the mid-1980s show an increasingly negative cohort effect as the birth years become more recent. It should be kept in mind that the data used, Table 2, relate to at-home consumption alone and beef eaten in McDonald's or Yoshinoya (gyu-don restaurants) is not counted.

Using these "pure" or net time effects with the demographic effects of aging and cohort-replacement of population accounted for, we next regress our estimates of annual period effects against the economic factors : changes in prices and income over the period in question.

$$(B + J_t) = a + b \log(RBFP_t) + c \log(REX_t) + e_t \quad (3)$$

$$= -12.16 + 0.64 \log(RPP_t) + 2.35 \log(REX_t)$$

$$(2.43) \quad (2.40) \qquad (3.16) \qquad \text{Adj. } R^2 = 0.205$$

B: grand mean effect (3.319, Table 4)

J_t : period effect for year t (Table 4)

$RBFP_t$: real average paid price of fresh beef in year t (yen/100 g : base year = 2005)

REX_t : real living expenditure/adult equivalence* in year t (10 thousand yen : base year = 2005)

e_t : random error

Table 2. Changes of At-Home Individual Beef Consumption by Age, 1980-2011 (100g/year)

	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+
1980	23.66	23.75	22.79	27.01	29.72	31.37	30.03	35.47	29.05	26.04	24.55	21.91	18.63
1981	24.58	22.48	20.50	28.81	31.99	32.57	37.88	37.23	33.16	22.15	22.44	20.83	17.95
1982	27.14	26.47	25.17	28.67	31.94	33.65	34.24	36.75	33.00	26.33	23.67	20.64	17.41
1983	26.65	25.09	23.63	27.19	33.19	31.59	38.09	35.77	35.91	27.05	23.07	19.53	16.25
1984	27.42	24.13	22.31	28.23	30.19	38.73	35.18	37.07	33.94	30.96	27.63	23.99	20.09
1985	29.61	25.65	22.23	26.69	29.54	34.05	39.40	35.75	31.22	30.22	26.52	22.88	19.09
1986	29.17	25.49	22.76	26.56	31.38	34.31	38.38	34.89	33.38	32.21	26.92	22.47	18.42
1987	30.21	26.64	23.98	28.51	32.59	38.69	43.04	39.66	40.10	28.94	24.26	20.57	17.16
1988	30.94	26.59	23.12	28.91	32.29	43.37	40.38	40.62	36.43	30.81	27.89	24.52	20.69
1989	33.17	28.85	24.96	27.65	32.84	38.75	42.42	38.95	34.46	34.47	29.58	25.22	20.82
1990	32.81	29.63	26.62	31.69	34.60	38.29	43.93	41.52	35.07	35.43	27.68	22.34	17.98
1991	33.23	30.68	28.22	32.12	35.58	40.80	44.49	43.34	39.92	35.00	31.70	27.81	23.38
1992	37.18	35.88	33.89	30.25	34.33	39.56	40.75	39.17	41.73	34.54	30.43	26.27	21.91
1993	36.81	33.80	29.30	31.60	36.69	41.86	50.26	47.09	38.15	37.18	33.11	28.86	24.20
1994	37.82	33.50	28.97	34.79	37.74	48.60	50.75	49.76	40.20	39.66	32.56	27.10	22.26
1995	38.16	35.26	31.81	34.74	39.63	46.09	51.65	50.12	44.04	41.89	32.67	26.36	21.36
1996	37.55	34.75	32.18	30.41	31.59	41.02	43.99	40.34	43.18	35.34	30.54	26.27	21.90
1997	35.84	32.53	29.29	28.47	34.61	42.55	44.99	42.82	43.18	38.27	32.77	27.87	23.07
1998	34.45	32.53	29.82	29.18	30.63	42.87	41.01	43.72	39.87	36.86	30.70	25.60	21.04
1999	30.98	27.84	25.27	29.60	31.52	42.99	42.69	44.18	41.38	37.78	33.75	29.24	24.40
2000	33.52	30.34	26.77	26.49	31.36	39.91	43.27	42.22	39.76	35.27	31.74	28.57	24.28
2001	29.46	27.37	24.55	21.67	24.37	31.85	34.62	33.59	32.33	29.52	25.73	21.45	17.48
2002	26.22	25.21	23.18	21.66	23.93	29.45	32.67	33.51	31.74	27.34	23.88	21.06	17.82
2003	24.78	23.16	21.99	22.13	25.10	30.23	31.77	30.89	32.01	32.44	29.51	24.50	19.82
2004	20.07	19.17	17.84	18.38	21.68	27.11	30.50	31.93	31.48	28.71	26.14	23.54	20.08
2005	17.87	16.15	14.27	17.56	22.83	28.98	32.99	34.69	33.16	28.79	26.23	24.53	21.35
2006	20.11	19.19	17.96	18.24	21.21	26.28	29.19	30.16	30.02	27.92	25.38	22.45	18.95
2007	17.32	16.22	15.28	17.41	21.46	26.82	30.02	31.40	32.07	30.59	27.25	22.87	18.77
2008	17.58	16.73	15.91	16.38	19.89	25.95	29.17	30.25	31.75	31.58	28.46	23.60	19.18
2009	18.03	18.02	17.79	18.88	21.84	26.49	29.92	32.21	33.49	32.21	28.52	23.57	19.21
2010	19.06	17.39	16.10	16.65	20.78	27.73	30.55	30.47	32.09	32.67	29.34	23.74	18.96
2011	17.27	16.79	16.65	18.36	21.42	25.46	27.85	29.07	30.78	31.00	28.58	24.46	20.22

Sources: Calculated by the author using *FIES* data classified by household head ages by TMI model.

* Oxford equivalence scale (="old OECD scale": OECD, 2009)
Number in parentheses: t value

Model (3) is questionable because the coefficient for own price, c proved positive. We will then introduce the price of the competing meats, weighted average prices of fresh pork and chicken in model (4) below.

$$(B+J_t) = a + b\log(RBFP_t) + c\log(REX_t) + d\log(RPCP_t) + e_t \quad (4)$$

$$= -27.79 - 0.45\log(RBFP_t) + 4.37\log(REX_t) + 2.39\log(RPCP_t)$$

(6.55) (1.77) (7.27) (6.03) Adj. $R^2 = 0.642$

$RPCP_t$: real average paid price[1] of fresh pork and chicken in year t (yen/100 g: base year = 2005)

Table 3. Individual At-home Beef Consumption Decomposed into Age/ Period/ Cohort Effects by Bayesian Estimator

Grand Mean Effect = 28.98 (0.22) (100 g/1 person)

Age Effects Age		(SD)	Period Effects Year		(SD)	Cohort Effects Born in		(SD)
15–19	−1.06	1.14	1980	−2.08	0.80	1906–10	−3.31	2.11
20–24	−3.95	1.15	1981	−1.43	0.78	1911–15	−3.52	2.12
25–29	−6.80	1.20	1982	−0.57	0.78	1916–20	−3.90	2.14
30–34	−5.19	1.24	1983	−0.51	0.78	1921–25	−4.10	2.14
35–39	−2.05	1.35	1984	0.24	0.77	1926–30	−2.44	2.08
40–44	3.52	1.49	1985	−0.09	0.76	1931–35	−0.24	1.97
45–49	6.15	1.49	1986	0.23	0.76	1936–40	1.30	1.87
50–54	5.95	1.35	1987	1.51	0.78	1941–45	3.02	1.74
55–59	4.53	1.24	1988	2.19	0.80	1946–50	4.49	1.68
60–64	2.31	1.20	1989	2.62	0.83	1951–55	4.52	1.67
65–69	−0.31	1.15	1990	3.31	0.86	1956–60	3.31	1.71
70–74	−3.11	1.14	1991	4.85	0.88	1961–65	1.52	1.89
			1992	5.19	0.88	1966–70	0.46	2.08
			1993	6.62	0.89	1971–75	1.20	2.00
			1994	7.84	0.90	1976–80	1.75	2.07
			1995	8.28	0.91	1981–85	1.67	2.15
			1996	5.32	0.91	1986–90	0.35	2.14
			1997	5.22	0.90	1991–95	−2.42	2.14
			1998	4.11	0.89	1996～	−3.64	2.16
			1999	3.81	0.89			
			2000	2.66	0.89			
			2001	−2.38	0.86			
			2002	−3.98	0.83			
			2003	−3.80	0.80			
			2004	−5.83	0.78			
			2005	−6.01	0.76			
			2006	−6.64	0.76			
			2007	−6.59	0.77			
			2008	−6.51	0.78			
			2009	−5.58	0.78			
			2010	−5.75	0.78			
			2011	−6.28	0.80			

Source : Calculated by the author using the data provided in Table 2.
Notes : $\Sigma A_i = \Sigma J_t = \Sigma C_k = 0$; (SD) = standard deviation.

[1] Constant weights of 2 to 1 are applied to pork and chicken in deriving average prices.

By adding the aggregate price of pork and chicken to the model, we have obtained a seemingly reasonable own price elasticity, in respect of sign and magnitude. The elasticity of substitution carries the right sign but may be too large in magnitude (M. Sawada, 2012, p. 191). More troublesome is that the estimated expenditure elasticity, 4.4, appears to be far too large (Obara, McConnel, and Dyck, 2010, pp. 13–14 ; Saegusa and Mori, 2012 ; also see subsequent footnote 2).

As mentioned above, the beef market in Japan underwent two major incidents : O-157 in the mid–1990s and BSE in the early 2000s. Therefore, we introduce dummy variables into our regression model, to represent these incidents. We first incorporate a dummy for BSE.

$$(GM + J_t) = a + b\ \log(RBFP_t) + c\ \log(REX_t) + d\ \log(RPCP_t) + f\ I_1 BSE + e_t \qquad (5)$$

$$= -4.08 - 0.29\ \log(RBFP_t) + 1.42\ \log(REX_t) + 0.40\ \log(RPCP_t) - 0.287^{*}\ I_1\ BSE$$

$$(1.67) \quad (2.95) \qquad (4.41) \qquad (1.88) \qquad (12.93) \quad \text{Adj. } R^2 = 0.948$$

Table 4. Individual At-home Beef Consumption Decomposed into Age/Period/Cohort Effects by Bayesian Estimator

Grand Mean Effect = 3.319 (0.008) (in natural log)

Age Effects			Period Effects			Cohort Effects		
Age		(SD)	Year		(SD)	Born in		(SD)
15–19	−0.170	0.071	1980	−0.047	0.043	1906–10	−0.156	0.118
20–24	−0.136	0.059	1981	−0.035	0.041	1911–15	−0.164	0.104
25–29	−0.257	0.047	1982	−0.001	0.039	1916–20	−0.161	0.093
30–34	−0.195	0.035	1983	−0.002	0.037	1921–25	−0.140	0.080
35–39	−0.077	0.023	1984	0.024	0.034	1926–30	−0.064	0.068
40–44	0.101	0.014	1985	0.014	0.032	1931–35	0.002	0.055
45–49	0.180	0.014	1986	0.023	0.030	1936–40	0.054	0.043
50–54	0.188	0.023	1987	0.054	0.028	1941–45	0.108	0.031
55–59	0.162	0.035	1988	0.078	0.026	1946–50	0.159	0.022
60–64	0.103	0.047	1989	0.096	0.025	1951–55	0.175	0.017
65–69	0.026	0.059	1990	0.115	0.023	1956–60	0.149	0.021
70–74	−0.077	0.284	1991	0.160	0.021	1961–65	0.104	0.030
			1992	0.174	0.020	1966–70	0.070	0.041
			1993	0.207	0.019	1971–75	0.085	0.053
			1994	0.234	0.018	1976–80	0.079	0.066
			1995	0.243	0.018	1981–85	0.047	0.079
			1996	0.174	0.018	1986–90	−0.018	0.092
			1997	0.168	0.018	1991–95	−0.138	0.104
			1998	0.138	0.019	1996〜	−0.190	0.115
			1999	0.126	0.020			
			2000	0.090	0.021			
			2001	−0.062	0.023			
			2002	−0.118	0.025			
			2003	−0.116	0.026			
			2004	−0.198	0.028			
			2005	−0.220	0.030			
			2006	−0.230	0.032			
			2007	−0.239	0.034			
			2008	−0.235	0.037			
			2009	−0.195	0.039			
			2010	−0.202	0.041			
			2011	−0.218	0.043			

Sources and Notes : the same as Table 3.

I_1 : Indicator variable for BSE = 1, if $t > 2000$

The addition of a BSE dummy improved the model's statistical performance and the parameter estimates for own price and substitution and expenditure elasticities look reasonable. We next add a dummy for O-157, thought to have damaged beef consumption relatively less than BSE (Ishibashi, 2012).

$$(GM + J_t) = a + b\ \log(RBFP_t) + c\ \log(REX_t) + d\ \log(RPCP_t) + f\ I_1\ BSE + gI_2\ O\text{-}157 + e_t \qquad (6)$$

$$= -1.92 - 0.56\log(RBFP_t) + 1.27\log(REX_t) + 0.45\log(RPCP_t) - 0.341^{*}I_1\ BSE - 0.112^{*}I_2 O\text{-}157$$

$$(6.89)\quad (8.51)\qquad\qquad (6.89)\qquad\qquad (3.66)\qquad\qquad (23.49)\qquad (7.57)\quad \text{Adj. } R^2 = 0.983$$

I_1 : Indicator variable for BSE = 1, if $t > 2000$

I_2 : Indicator variable for O–157 = 1, if $t > 1995$, < 2001

The model fit is further improved by adding O-157 and all the parameter estimates look more reasonable with much higher t-values than model (5). In assigning the indicator variable for BSE, we first gave 0.3 for year 2001 and 1 for 2002, and 0 afterwards, since BSE was discovered in September 2001 and the market disruption is reported to have calmed down before the beginning of 2003 (Watanabe, 2004), which did not result in appreciable improvement from model (4), without a BSE dummy. We then assigned 1 to 2003, and 0 afterwards ; then another 1 to 2004 ; ――, to reach the best result, model (6). This process could be technically enhanced by "piece–wise linear regression" (Pindyck and Rubinfeld, 1981), for example.

A brief interpretation of model (6) above concerning the impacts of BSE and O-157, respectively is presented here. Average per capita consumption in 1995 is estimated from Table 4 as exp(3.319 + 0.243) = exp(3.562) = 35.23(100 g). As a coefficient for O-157 is determined at –0.112, average consumption after the incident could be estimated as exp(3.562–0.112) = exp(3.450) = 31.50(100 g) in actual value, i.e., per capita consumption should have dropped by (35.23–31.50) = 3.73(100 g) as a possible consequence of the O-157 incident. Similarly, theoretical per capita consumption in the year 2000 = exp(3.319 + 0.090) = exp(3.409) = 30.23. When a BSE coefficient = –0.341 is added, theoretical consumption is estimated as exp(3.409–0.341) = exp(3.068) = 21.50(100 g) in actual value, i.e., per capita consumption should have dropped by (30.23–21.50) = 8.73(100 g), as a possible consequence of the BSE incident.

We learned recently that a traditional A/P/C model could encounter some structural problems in identifying cohort parameters, period effects in particular, when a time trend in consumption is severely hampered by abrupt, irregular market forces, for example, "fads and fashion" in the case of wine in Japan (Rod and Beal, 2012) or the BSE incident in beef (Saegusa and Mori, 2012). We will replicate in the subsequent section the analysis undertaken in this section, using "augmented" cohort model with price and income pre-installed.

3. Decomposing Individual At-home Beef Consumption by Age by a New Cohort Model, "Augmented" with Price and Household Income

$$\mu_{it} = B + A_i + J_t + C_k + c\ RBPP_t + d\ REXP_t + e_{it} \qquad (7)$$

where

all the data are logarithmic

$RBPP_t$: real average paid price of beef in year t

$REXP_t$: real living expenditure/adult equivalence in year t

c : constant price elasticity

d : constant expenditure elasticity

The results are provided in Table 5, which demonstrates that the "net" time effects are gradually declining to the mid-1990s and then dropped suddenly in 1996 and again sharply in 2001, with the effects of changes in price and household income over the entire period accounted for[2]. We suspect that these two abrupt drops in the period effect should represent possible impacts of O-157 and BSE, respectively, on individual at–home beef consumption.

When converted into actual numbers in 100 g per year (the 2nd column of Table 5), the theoretical base, so to speak, of individual at-home beef consumption is estimated as exp (3.321 + 0.177) = 33.05 (100 g) in 1980, which gradually fell to exp (3.321 + 0.110) = 30.91 in 1995 and then abruptly fell by 186g to exp (3.321 + 0.048) = 29.05 in 1996–1997. It is suspected that this fall could be attributed to

Table 5. Individual At-Home Beef Consumption Decomposed into Age/Period/Cohort Effects by Bayesian Estimator Augmented by Price and Income

Grand Mean Effect = 3.321 (0.008) (in natural log)

Est. Price Elast. = −0.559 (0.213) ; Est. Expenditure Elast. = 0.839 (0.592)

Age Effects			Period Effects			Cohort Effects		
Age		(SD)	Year		(SD)	Born in		(SD)
15–19	0.020	0.041	1980	0.177	0.075	1906–10	−0.102	0.076
20–24	−0.106	0.042	1981	0.170	0.076	1911–15	−0.110	0.077
25–29	−0.233	0.043	1982	0.175	0.070	1916–20	−0.112	0.078
30–34	−0.178	0.045	1983	0.157	0.064	1921–25	−0.099	0.078
35–39	−0.066	0.049	1984	0.160	0.060	1926–30	−0.029	0.075
40–44	0.104	0.054	1985	0.145	0.055	1931–35	0.029	0.072
45–49	0.177	0.054	1986	0.145	0.050	1936–40	0.074	0.068
50–54	0.177	0.049	1987	0.154	0.049	1941–45	0.122	0.063
55–59	0.145	0.045	1988	0.148	0.053	1946–50	0.166	0.061
60–64	0.079	0.043	1989	0.151	0.055	1951–55	0.175	0.060
65–69	−0.004	0.042	1990	0.150	0.054	1956–60	0.143	0.062
70–74	−0.115	0.041	1991	0.159	0.050	1961–65	0.090	0.068
			1992	0.139	0.049	1966–70	0.050	0.076
			1993	0.125	0.047	1971–75	0.058	0.073
			1994	0.115	0.042	1976–80	0.045	0.075
			1995	0.110	0.041	1981–85	0.006	0.078
			1996	0.048	0.040	1986–90	−0.065	0.078
			1997	0.048	0.039	1991–95	−0.191	0.077
			1998	0.022	0.038	1996～	−0.249	0.078
			1999	0.003	0.036			
			2000	−0.041	0.034			
			2001	−0.173	0.034			
			2002	−0.218	0.032			
			2003	−0.192	0.031			
			2004	−0.230	0.031			
			2005	−0.240	0.030			
			2006	−0.233	0.034			
			2007	−0.240	0.033			
			2008	−0.229	0.039			
			2009	−0.216	0.045			
			2010	−0.241	0.043			
			2011	−0.245	0.043			

Sources and Notes : the same as Table 3.

[2] The own price and expenditure elasticities are determined at−0.56 and 0.84, respectively (on the upper part, Table 5), which seem to be realistic (see Obara, McConnel, and Dyck, op. cit. and Saegusa and Mori, op. cit.). Concerning income elasticities of household demand for beef, we conducted cross-sectional analyses of *FIES* data, classified by 17–18 income classes in 1985 and 1995, to obtain the average elasticities of 0.7 to 0.8.

$$\log(capQ_i) = a + b \log(EX_i) + e \qquad (8)$$

$$1985: \quad = -0.548 + 0.79 \log(EX_i)$$

$$(2.08) \quad (14.42) \qquad AdjR2 = 0.963$$

$$1995: \quad = 0.080 + 0.69 \log(EX_i)$$

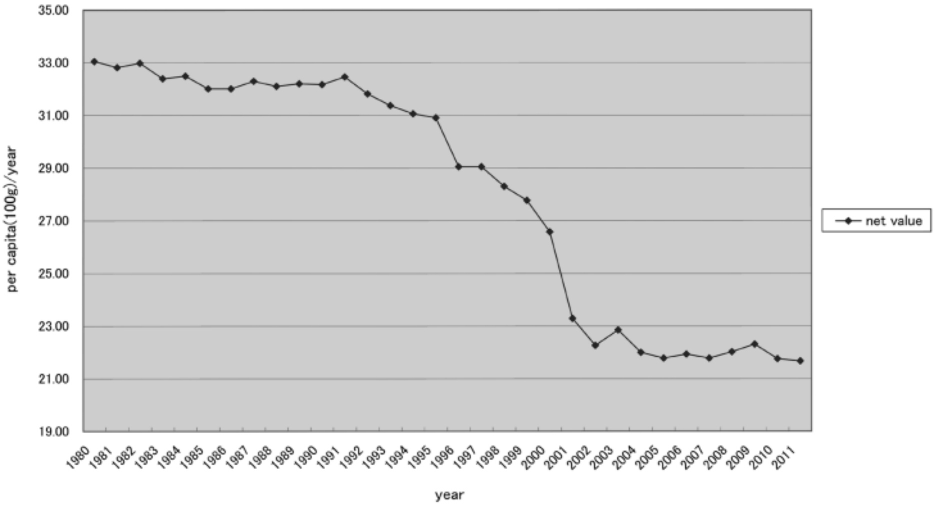
$$(0.26) \quad (11.15) \qquad AdjR2 = 0.925$$

where

$capQ_i$: per capita beef purchase (100g) by i^{th} household by annual income class

EX_i : per adult expenditure (10 thousand yen) of i^{th} household by annual income class

Fig. 2 At-Home Beef Consumption after Accounting for Age/Cohort Effects and Price and Income Effects, 1980-2011



the incident of O-157. The same consumption base is estimated as exp (3.321–0.041) = 26.58(100 g) in 2000, which fell to exp (3.321– 0.173) = 23.29 in 2001 and exp (3.321–0.218) = 22.26 in 2002, by approximately 400 g. These abrupt decreases could be attributed to the incident of BSE, which occurred in the fall of 2001 in Japan.

The "theoretical base" of at-home beef consumption then declined a little further to exp (3.321–0.240) = 21.78(100 g) in 2005 and stayed virtually unchanged to 2011 (Fig. 2). What may call for attention is that the consumption base of Japanese at–home beef consumption has not recovered to the mid-1990s' level, whether due to persisted impacts of O-157 and BSE incidents and/or some other factors.

Japanese beef has been characterized as very expensive by international standards (Hayami, 1979 ; Longworth, 1983 ; Coyle, 1986 ; etc.). Japanese beef has become substantially cheaper since the early 1980s, because of the freer trade and appreciably stronger yen against the U.S. and Australian dollars (Mori and Gorman, 1995). And yet, beef is much more expensive than other meats, a little more than twice as high as pork, and three times higher than chicken in Japan at present. In a long-stagnated economy, Japanese consumers have been shifting from beef to cheaper meats (alic, Research Department, 2012). Mainly due to the suspension of grain–fed beef imports from North America, the average retail price of fresh beef increased nearly 20% from 2000 to 2008, whereas that of pork and chicken kept unchanged. At-home, Japanese consumers ate nearly 10% more meats in 2011 than in 2000. As is shown in Table 6, household purchases of beef decreased from 10.1 kg in 2000 to 6.8 kg in 2011, whereas that of pork increased from 16.0 to 19.0 kg and that of chicken rose from 11.6 to 13.7 kg during the same period. Our research provides strong indications that shocks from the O-157 and BSE incidents as well as the changes of beef price relative to substitutes, were responsible for some of the decline in at–home beef consumption. Our results also show that, for at-home consumption, young people consume below-average amounts of beef. Further research about beef consumption by young people away from home is needed to determine whether the preference for beef will decline in the future.

Table 6. Household Purchases of Beef, Pork and Chicken, 2000-2011

	Beef			Pork			Chicken		
	Quantities	Paid Prices		Quantities	Paid Prices		Quantities	Paid Prices	
	kg/year	yen/100g	index	kg/year	yen/100g	index	kg/year	yen/100g	index
2000	10.099	258.84	100.0	16.040	134.33	100.0	11.591	91.49	100.0
2001	8.205	257.49	99.5	16.341	135.45	100.8	11.644	92.80	101.4
2002	7.694	260.94	100.8	17.010	136.80	101.8	12.061	94.56	103.4
2003	7.963	270.07	104.3	16.365	133.55	99.4	11.618	92.27	100.9
2004	7.113	296.66	114.6	17.335	135.16	100.6	10.944	93.03	101.7
2005	7.195	296.38	114.5	17.407	133.23	99.2	11.647	92.29	100.9
2006	6.891	300.45	116.1	17.305	134.35	100.0	11.985	90.70	99.1
2007	6.869	303.82	117.4	17.723	134.98	100.5	12.379	91.24	99.7
2008	6.776	308.24	119.1	18.310	139.57	103.9	12.661	101.33	110.8
2009	7.032	286.8	110.8	18.639	133.00	99.0	13.647	92.44	101.0
2010	6.922	273.98	105.8	18.498	129.51	96.4	13.753	90.06	98.4
2011	6.782	274.15	105.9	18.987	130.30	97.0	13.702	93.43	102.1

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