

## Discussion of Age, Period, and Cohort Effects

Results of the A/P/C analysis (tables 5 and 6) indicate that the cohort effects are roughly as important as age effects and that both are substantially more important than “pure” period effects in explaining the changes in individual at-home consumption of oranges during the past decades in Japan. Period effects are the residual after the age and cohort effects are subtracted from the estimates of individual consumption at various ages. Period effects are, thus, not an ordinary time trend but a quantity variable unique to each year with age and cohort effects controlled.

Japanese consumers eat more oranges as they age to the oldest group, 75 and older, whereas those younger than the mid-thirties, in particular, eat substantially fewer oranges than those older than age 60. At the same time, the younger generations born after the mid-1960s are found to consume many fewer oranges than the older generations who were in their late thirties through sixties in the mid-1980s. For easier visual interpretation, the following examples draw on table 6. All consumers can be thought to begin with 782 grams, the grand mean of orange consumption over the whole sample. Membership in the age group 15-19 (column 1, table 6) is estimated to subtract 252 grams (g) from orange consumption, just by virtue of being young. Someone in the group age 75 and older is estimated to add 332 g to consumption. In addition to the other factors, birth cohort membership also

Table 6

### Changes in individual consumption of fresh oranges, decomposed into age, period, and cohort effects

Age effects: $A_i$		Period effects: $P_t$		Cohort effects: $C_k$	
Age groups (years)	Grams	Calendar year	Grams	Years born	Grams
15-19	-251.5	1987	146.6	~ 1912	-165.2
20-24	-241.4	1988	7.7	1913-17	-20.5
25-29	-222.7	1989	41.2	1918-22	186.8
30-34	-143.3	1990	111.5	1923-27	255.0
35-39	-12.7	1991	-222.9	1928-32	301.1
40-44	50.6	1992	141.8	1933-37	302.8
45-49	40.6	1993	183.9	1938-42	256.4
50-54	9.1	1994	306.3	1943-47	181.7
55-59	1.3	1995	242.4	1948-52	133.8
60-64	44.4	1996	75.9	1953-57	-42.9
65-69	138.3	1997	177.8	1958-62	-154.7
70-74	255.4	1998	62.9	1963-67	-209.7
75 ~	331.8	1999	-355.6	1968-72	-189.3
		2000	-63.5	1973-77	-187.3
		2001	-91.7	1978-82	-232.6
		2002	-154.7	1983-87	-184.2
		2003	-138.4	1988 ~	-231.2
		2004	-183.5		
		2005	-175.6		
		2006	-112.2		

Note: Grand mean for the sample is 781.9 grams.

~ means lower than or equal to, before a number, and older than or equal to, after a number.

Source: Estimates based on minimization using original data (not transformed into logarithms).

changes consumption (column 3, table 6). Membership in the peak orange-eating cohort, born in 1933-37, adds 303g to consumption. Membership in the cohort that eats the least oranges, born in 1978-82, subtracts 233g from consumption. Cohorts born before 1950 tend to eat, on average, 300~500g more oranges than those newer cohorts born after the mid-1970s. Those who will reach their forties in 2017 (born 1968-77) are predicted to eat 400g less oranges than those who were in their forties in the mid-1980s, for example.

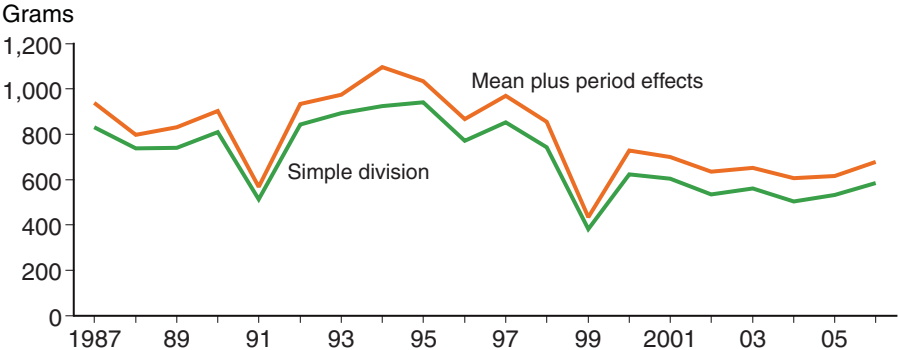
The period effects plus the grand mean show annual consumption per person, with age and cohort effects excluded. Comparison of the period effects plus the grand mean with the consumption per person derived by simple division shows that the two results moved in the same directions over time (fig. 4). In all years, the period effect plus the grand mean is higher than the result from simple division. The difference is the contribution of the summed age and cohort effects, which must have been negative.<sup>14</sup>

Changes in “pure” period effects derived from the A/P/C analysis seem to be slightly larger in absolute magnitude than those measured in simple consumption per person from the mid-1980s to the mid-1990s on the upward swing, and again somewhat larger in absolute magnitude from the mid-1990s to the mid-2000s on the downward swing. The aging of the population had a positive impact on total consumption, whereas the replacement of the older generations by younger generations had a negative effect (usually with a slightly larger absolute magnitude). On balance, it seems as if the demographic factors—population aging and generational replacement—mostly cancelled each other out in the case of orange consumption in the past two decades. However, will this continue to be the case in the future?

Cohort effects are quite significant in explaining the changes in orange consumption. Japan’s future economy is not easy to predict, but it is quite certain that the older generations born before the mid-20<sup>th</sup> century—fruit-eating cohorts—will be steadily replaced by newer generations who tend to eat relatively little fresh fruit, for unidentified reasons. To illustrate the implications of cohort changes on orange consumption, the analysis simulates likely individual consumption by age to the year 2017, using the cohort parameters estimated earlier (see table 5 in logs). Table 7 projects individual consumption of oranges by age in 2007 and 2017 (also in 2027, with less confidence), synthesizing estimated cohort

<sup>14</sup>The comparison is made with the estimates using actual weights reported in table 6, rather than results from estimation using logarithms in table 5.

Figure 4  
**Orange consumption by individuals in Japan**



Source: Mean plus period effects from weights reported in table 6 (rather than logarithmic values in table 5); simple division from household observations divided by number of persons in the household.

parameters: grand mean effect + age effect + period effects + cohort effects (and then transformed into actual numbers in grams). The period effects for the years 2007 and 2017 have not been determined, and it is assumed that they will remain at the 3-year average of 2004, 2005, and 2006. The cohort effects for the “newcomers,” who will be ages 15-19 and 20-24 in 2017, have not been estimated, and it is assumed that they will take the same values of the newest two cohorts, who were ages 15-19 and 20-24 in 2006.

In the mid-1980s through the mid-1990s, young Japanese under age 35 consumed on average more than 50 percent fewer oranges than those in their fifties and sixties (fig. 5). The disparity between the young and the old in orange consumption has widened since then, with middle-aged adults also moving away from orange consumption. It is predicted that even those in their fifties will eat less than half the oranges than those in their seventies will eat in 2017, if the demographic tendencies observed during the past two decades are assumed to continue. Trends illustrated in figure 5 suggest that the decline in at-home orange consumption since the mid-1990s will accelerate further in the decades to come.

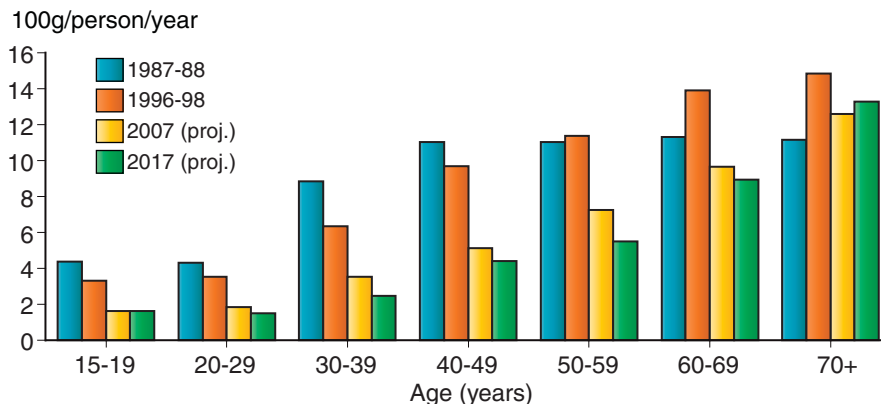
Table 7  
**Individual consumption of fresh oranges by age groups**

Age	Actual 1994-96 average	Projected 2007	Projected 2017	Projected 2027
<i>Grams/person</i>				
15-19	430	164	164	164
20-24	461	167	151	151
25-29	483	203	146	146
30-34	552	302	191	173
35-39	815	406	300	216
40-44	1,081	473	417	263
45-49	1,214	550	464	342
50-54	1,254	649	502	442
55-59	1,276	797	598	504
60-64	1,412	882	760	586
65-69	1,550	1,048	1,028	769
70-74	1,603	1,222	1,225	1,052
75 and up	1,566	1,291	1,426	1,394

Note: Period effects for the future years are assumed constant at the 2004-06 average.

Source: Synthesis of estimated cohort parameters in table 5.

Figure 5  
**Individual orange consumption in Japan by age group**



Source: USDA, Economic Research Service.