Consumer Cohorts and Milk Purchases

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Abstract— **Fluid milk is the most important product of Norwegian agriculture, and the decline in milk purchase has impact in many rural communities. By decomposing the milk purchase into cohort effects, age effects and year effects we show that the reason for the decline is that older generations purchase more milk than younger generations, and during lifetime consumption decline with age. Consequently, as younger generations replace older generations milk purchase decline. We show that towards 2021 the milk purchase will continue to fall.**

Keywords— **Milk, Purchases, Cohorts**

I. INTRODUCTION

Norwegians are heavy milk drinkers, however, the consumption of fluid milk has declined steadily over the last twenty years. Over the period 1986 to 2006, the per capita purchases of fluid milk were reduced by more than a third. This reduction has partly been offset by increased consumption of cheeses and some other diary products but the total milk production declined about 15% over the period according to the Norwegian Agricultural Economics Research Institute, NILF [1, 2].

Milk is the most important product in Norwegian agriculture, and about one third of total income comes from dairy production. Although agriculture only contributes to 2.6% of the total employment, dairy production is important in many rural areas and reduced production affects rural communities across the country. Consequently, the demand for fluid milk is important for the future of these communities.

Several studies have investigated the Norwegian demand for fluid milk. Rickertsen [3] found an own-price elasticity of -0.27 and a total expenditure elasticity of 0.54 using annual data for 1962 – 1991 period. Using data for 4-months observation periods for the years 1978 – 2001, Gustavsen and Rickertsen [4] found that the own-price elasticity and total expenditure elasticities had been reduced to –0.14 and –0.03, respectively. Using the same data set but for the 1975 – 1995 period, Rickertsen and Gustavsen [5] found that the own-price elasticities of whole milk and low-fat milk were -0.14 and -0.68, respectively, while the own-advertising elasticity for fluid milk was found to be 0.0008. The estimated differences in numerical values may, at least, partly be explained by different sample periods and differences in the model specifications. In any case, the general conclusion from these studies is that the aggregate demand for fluid milk is quite inelastic with respect to changes in the price of milk, advertising, and income. These inelastic values suggest that economic factors alone cannot fully explain the observed decline in fluid milk consumption and reliably forecast future consumption. The inelastic demand responses corresponds generally well with studies in other countries. For a summary of such results; see for example Rickertsen and Gustavsen [5].

To provide additional insights, we use an alternative modelling strategy and follow cohorts of households, where the cohorts are defined by the age of the head of the household. We follow Deaton [6] and decompose purchases of milk into age, cohort, and year effects. Age effects make older individuals purchase differently than younger individuals regardless of cohort and year. Cohort effects make individuals from different generations purchase differently regardless of age and year. Year effects make the purchases of all age groups and all cohorts vary between years. Year effects may be explained by special events in specific years or changes in the economic conditions that affects all cohorts and age groups. Expected milk consumption for a specific age group, in a specific cohort, and in a specific year is found by adding the effects. The total effect of age, cohort, and year may resemble a trend and trend variables (e.g., Rickertsen and Gustavsen [5] and Gustavsen and Rickertsen [4] or habit persistence (e.g. Rickertsen [3]) have frequently been introduced into demand systems to improve the fit and forecasting abilities of the models.

To distinguish between age, cohort, and year effects may improve the explanatory power of the model and increase the reliability of forecasts of future purchases of milk. For example, assume that an age variable, but no cohort variables, is included in the model and a positive age effect is found. This effect could be explained in different ways. First, it could be explained by increased health awareness among older individuals leading to more healthy drinking habits and increased purchases of milk. If this explanation is true, then an increased average age of the population will result in increased future aggregate purchases. However, the effect could alternatively be explained by cohort effects where older cohorts purchase more than younger. Cohort effects could be explained by historical experiences. After the Second World War, milk was considered to be an important part of any healthy diet. However, the nutritional value of milk has been questioned and milk's nutritional status has declined among younger generations. If the latter explanation is true, then the replacement of older with newer generations will result in decreased future aggregate purchases. To further investigate these alternative scenarios, we follow Deaton [6] and create pseudo panels of household data. Using these pseudo panels, we construct cohort–year pairs and decompose the milk purchases into age, cohort, and year effects.

II. AGE, COHORT, AND YEAR EFFECTS

We decompose milk purchases as

$$Q = \beta + A\alpha + C\gamma + Y\psi + u \qquad (1)$$

where Q is the stacked vector of cohort–year pairs, A a matrix of age dummies, C a matrix of cohort dummies, and Y a matrix of year dummies. The cohort data are arranged as cohort–year pairs, with each observation corresponding to a single cohort in a specific year. If there are n such cohort–year pairs, the three matrices will each have n rows. The number of columns will be the number of age groups, the number of cohorts, and the number of years, respectively. Each row corresponds to a single observation of the logarithm of the average milk purchases of a cohort group in a specific year. Because each of the matrices is singular, we have to drop one age dummy, one cohort dummy, and one year dummy from the estimation. Furthermore, there exists an additional linear relationship across the three matrices. If we know the year of an observation and when the observed cohort was born, then we can infer the age of the cohort. We follow Deaton [6, p. 126] and impose the orthogonality restriction $s'\psi = 0,$ where ψ is the parameter vector of the year effects in equation (1), and s = (0, 1, 2, …, 15) is a trend where s = 0 represents the year 1986 and s = 15 represents the year 2001. The year dummies in the Y matrix are redefined to $y_t^* = y_t - [(t-1)y_2 - (t-2)y_1]$ for t = 3, …, 15, where y_t is the year dummy that is equal to 1 if the year is t and zero otherwise. This procedure enforces the restriction $s'\psi = 0$ and, furthermore, the restriction that the year effects have to sum to zero.

III. DATA AND EMPIRICAL IMPLEMENTATION

The household expenditure surveys cover the 1986–2001 period and are described in Statistics Norway [7]. In the surveys, the country is divided into sampling areas corresponding to the more than 400 counties of Norway. These sampling areas are grouped in 109 strata, and a sample area is randomly drawn from each stratum. Sampling areas are drawn with a probability proportional to the number of persons living in the area. Next, persons are randomly drawn from the 109 sampling areas such that the sample becomes self-weighting. When a person is drawn, the household of that person is included. Finally, these households are randomly drawn to record their expenditures in one of the 26 two-week survey periods of the year. Each year 2,200 persons are initially drawn. The non response rate varies between 33 and 52 percent and our total sample consists of about 20,500 cross-sectional observations.

The household expenditure surveys are repeated every year and we follow cohorts of households. The cohorts are defined by the age of the head of the household. Our oldest cohort was between 58 and 62 years old in 1986. For simplicity, we refer to the age of this cohort as 60 years old in 1986, 61 years old in 1987, up to 75 years old in 2001. This cohort was around twenty years old by the end of the Second World War. Correspondingly, we define eight additional cohorts who were 55, 50, 45, 40, 35, 30, 25, and 20 years old in 1986. In 1991 we added the cohort group who was between 18 and 22 years old in that year, and in 1996 we added the cohort group who was between 18 and 22 years old in that year. In total, 11 cohort groups were defined in 2001. For example, the cohort born in 1961 was 25 years old in 1986, 35 years old in 1996, 40 years old in 2001, and will be 60 years in 2021. The cohort born in 1961 were 25 years in 1986, the cohort born in 1966 were 25 years old in 1991, the cohort born in 1971 were 25 years old in 1996, and so on.

The average per capita purchases of households with a head aged 25 years old were 134 litres in 1986, 120 litres in 1991, 92 litres in 1996, and 56 litres in 2001. At this age, older generations purchased more milk than younger generations did, i.e., cohort effects. Furthermore, there are substantial age effects. For all cohorts, milk purchases decline with age. A household born in 1966 purchased 124 litres per capita in 1986, i.e. when the head was 20 years old. 15 years later, in 2001, a corresponding household purchased 76 litres per capita, i.e., a 39% reduction. A household born in 1926 purchased 146 litres per capita in 1986 and 107 litres in 2001, i.e., a 27% reduction. For all cohorts, there are similar declines with age in milk purchases. These age effects are a natural part of getting older. In general, older people use less energy than younger people, hence they consume less milk.

For each cohort–year pair, we computed the natural logarithm of the average milk purchases per capita weighted by the inverse of the probability of participating in the survey. Following Deaton [6, p. 124], we assumed away interaction effects between age, cohort, and years, and decomposed logarithm of milk purchases into age, cohort, and year effects.

IV. RESULTS

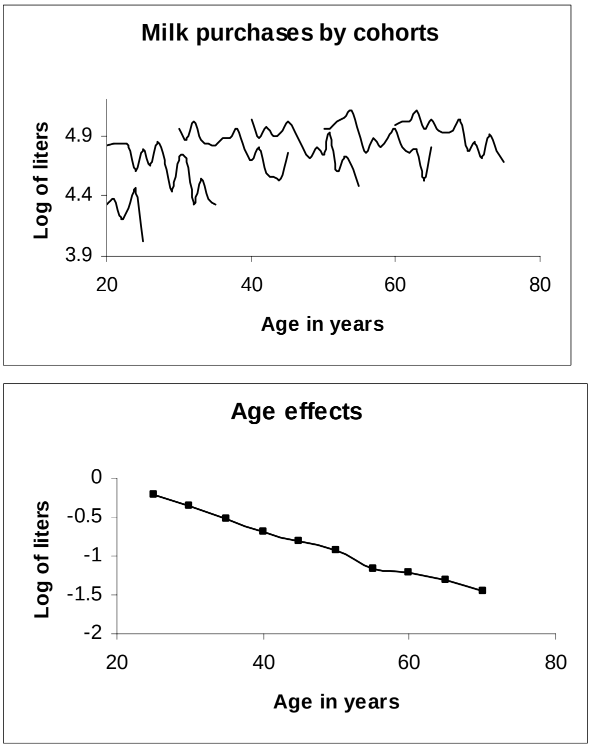
We estimated equation (1) using ordinary least squares. The first age dummy and the first cohort dummy were dropped from estimation, so the age effects are compared with a household with head aged 20 years old and the cohort effects are compared with the cohort where the head of the household was 20 years old in 1996. The year dummies for 1986 and 1987 were dropped from the estimation, but recovered from the adding-up and orthogonality restrictions.

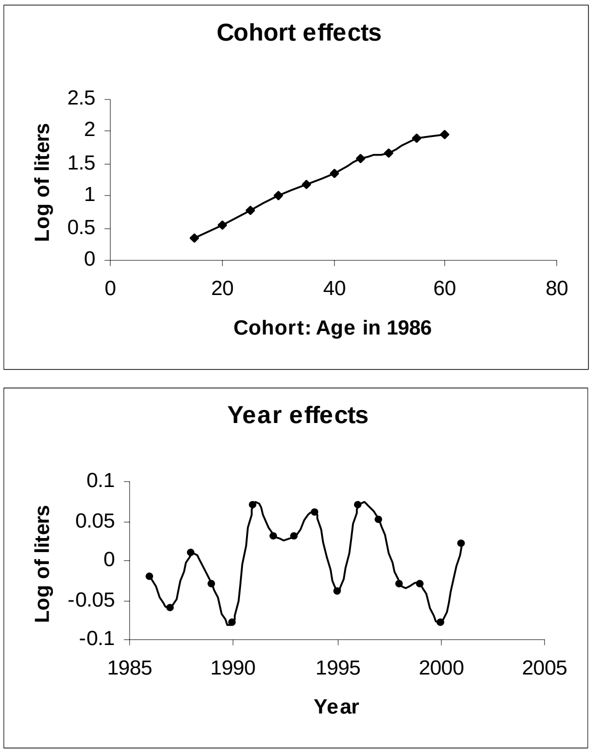
The regression results show that all the age and cohort effects, and some of the year effects, are significantly different from zero and the R^2 is 0.85. The age effects are relative to a household with a head aged 20 years old, and the cohort effects are relative to the cohort born in 1976. The age, cohort and year effects are reproduced in figure 1. The age effects show the expected difference in the logarithm of milk purchases between a 20-year-old person and persons of other ages, regardless of generation or year. Likewise, the cohort effects show the expected differences in the logarithm of milk purchases for each generation compared to the generation born in 1996, disregarding age and year. In reality we cannot disregard age, cohort, or year, because there exists an exact linear relationship between these variables. An individual has to belong to a generation, have an age and make purchase in a year.

The upper left panel of figure 1 shows the development of the logarithm of milk purchases of the different cohorts over time. For clarity of exposition just six of the 11 cohorts are shown, but the pattern is similar for the other cohorts as well. The top line shows the oldest cohort while the bottom short line shows the youngest cohort. The other cohorts are in between. Several effects are evident from this panel. First, there are substantial cohort effects. The line for an older cohort is always above the lines for a younger cohort when they are observed at the same age. As mentioned above, these cohort effects may be explained by historical experiences. The generations who grew up around the Second World War often suffered from food shortages and milk was an important nutritional element.

The upper right and the two lower panels of figure 1 show the age, cohort, and year effects. These effects are the coefficients of equation (1) where the year effects are restricted to sum to zero. So the age effect is the difference in log of milk purchases between a 20-year-old person and persons of other ages. The cohort effects are the difference of log of milk purchases between the cohort born in 1976 and other cohorts. The year effects vary around zero. The age effects are negative and the cohort effects are positive and both effects are of similar magnitudes. The older a person is, the less milk that person buys. Moreover, the older a cohort is, as compared with the cohort born in 1976, the more milk a person belonging to that cohort buys. The year effects are very small compared with the other effects.

Figure 1. Milk purchases by cohorts and their Decomposition





V. TREND EXTRAPOLATIONS

Using the results in figure 1, we can find the expected milk purchase for a given age, cohort, and year as

$$E(\hat{Q} \mid A, C, Y) = e^{\hat{\beta} + \sum \hat{\alpha}_i A_i + \sum \hat{\gamma}_j C_j + \sum \hat{\psi}_k Y_k + 0.5\hat{\sigma}^2} \quad (2)$$

where the last term in the exponential is the standard error of the residuals. This correction factor has to be included because we take the expectation of an exponential (Miller [8]). This extrapolation for three different cohorts in 2021 is shown in table 1

Table 1. Milk purchases in selected cohorts and years

Cohort born	2001 Litres	2021 Litres	Diff %
1939-1943	108	85	-21
1954-1958	95	56	-41
1969-1973	75	41	-45

The cohorts not shown in table 1 have the same pattern as those shown in table 1. In all cohorts the purchase is expected to continue declining towards 2021 because positive cohort effects and negative age effects. And this may aggravate the problems of the rural communities most dependent upon agriculture.

VI. CONCLUSIONS

The positive effect on purchases of increasing age has sometimes been attributed to increased health awareness among older people. However, the results of our cohort analysis suggest that older generations purchase more than younger generations while age by itself has a negative impact on milk purchases. A household will purchase less milk as it gets older, but still purchase more than an identical household from a younger generation. The replacement of generations will continue and further decreases in milk purchases are likely. Decreasing milk purchases are likely to reinforce the problems of agriculture and many rural communities.

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