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Consumer cohorts and the demand for meat and dairy products

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ABSTRACT

Over their life course, people change their consumption habits when prices, income, tastes or nutritional needs change. The time period during which an individual grew up is often reflected in his or her consumption of different types of food. To investigate the possible links between demographic changes and food consumption, we constructed two-step censored demand systems for different groups of foods. We estimated the systems using Norwegian data for the 1986 – 2012 period. In the systems, age, period, cohort, other demographic and economic variables are included. The estimated systems are used to construct a long-run forecasting model for meat and dairy products. In this model, younger cohorts replace older cohorts with a different consumption pattern. The total purchases of beef, lamb, pork and fluid milk are predicted to decrease, while the total purchases of chicken, yoghurt and cheese are predicted to increase towards 2027.

Keywords: Age-period-cohort; dairy; demand systems; long-run forecasts; meat.

Introduction

In the long run, behavior change slowly. Individuals are born, grow up, get married, get children, become old and die. During their life course, people change their behavior, taste and nutritional needs. While young people may be less risk averse and often look for pleasure, older people often become aware of their short remaining time and become more health conscious. In addition, the culture and taste in the society during childhood years often shape food consumption as well as other life styles. For example, the status of milk as a nutritional source was very high before and after World War 2. At the time, nutritional experts recommended that people should drink a liter of whole milk every day. As a result, older cohorts used to drink a lot of milk when they grew up, and they continued to drink milk as they grew older. In the 1970s and 1980s, the health benefits of whole milk were questioned due to its high content of saturated fat. As a consequence, the nutritional status of milk declined, and younger cohorts grew up drinking less milk than their parents did when they were at the same age.

When demand models for food are used for long-run forecasting, it may improve their forecasting abilities to account for changes in age, period and cohort (APC) variables over time. Food consumption will change slowly as younger cohorts gradually replace older cohorts. Our objective is to make long-run forecasts

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for at-home purchases of meat and dairy products in Norway. To make these forecasts, we use the model in Gustavsen and Rickertsen (2014), who incorporated the APC model of Deaton and Paxton (1994) into a censored demand system. This method has also been used in Qian et al. (2018), who estimated the demand US for meat and made long-run forecasts for the purchases of different types of meat.

To take account of a large number of food commodities, we assumed a weak separability structure and modelled the demand within a two-stage demand system. In the first stage, we estimated the demand for broad groups of food commodities and other non-durables and services. In the second stage, we estimated conditional demand systems for each of the broad groups of food defined in the first stage. Finally, we used the first-stage elasticities to correct the conditional elasticities estimated in the second stage to calculate the unconditional elasticities. For this purpose, we used the formulas described in Edgerton (1997) and Carpentier and Guyomard (2001). In a similar way, we estimated age and cohort effects and used these in the long-run forecasting model.

In the next section, we describe the data, commodity specification of the two-stage model, and the construction of price variables. Next, we present our demand model with APC variables, and describe the construction of conditional and unconditional price, expenditure, and APC effects in our two-stage demand model. Finally, we assume constant relative prices and real total expenditures, and make long-run forecasts where younger cohorts replace older cohorts as time passes.

Data

The Norwegian household consumption expenditure surveys (CES) cover the 1986–2012 period and are described in Statistics Norway (1996). Until 2009 the surveys were annual, however, there was no survey in 2010 or 2011. In 2012, a survey with three times as many participants as in the previous surveys was completed.

In the surveys, the country was divided into sampling areas corresponding to the more than 400 counties of Norway. These sampling areas were grouped into 109 strata, and a sample area was randomly drawn from each stratum. Sampling areas were drawn with a probability proportional to the number of persons living in the area. Next, persons were drawn randomly from the 109 sampling areas such that the sample became self-weighting. When a person was drawn, the household of that person was included. Finally, the included households were drawn randomly to record all their expenditures in one of the 26 two-week survey periods of the year. Each year (except from 2012), 2,200 persons were initially drawn. The nonresponse rate varied between 33% and 52%, and our total sample consists of 32 410 cross-sectional observations. For food products[1] expenditure and quantities were recorded, but for all other commodities and services, just expenditures were recorded.

We assume that the consumers make their purchase decisions in two stages. First, they choose how much to spend on broad categories of non-durables and services. Then, conditional on the total expenditure allocated to each of these broad categories, the consumers choose how much to spend on the specific items included in each of the first-stage categories.

Figure 1 shows the separability structure and commodity specification in the model. Five broad categories are specified: meat and fish, dairy and egg, vegetabilia, drinks, and other nondurables and services. The meat and fish category consists of: beef and lamb (including meat balls); pork (including sausages), chicken, and fish. The dairy and egg category consists of: egg, cheese, yoghurt (including cream and sour cream), fats

[1] Household purchases from supermarkets and food stores are included. Food eaten at cafeterias, restaurants and fast food outlets and purchases to hospitals, military camps or retirement homes are not included.

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(butter, margarine and oils), and other foods (mainly of industrially prepared foods). The vegetabilia category consists of: vegetables (including potatoes), fruits (including berries and nuts), cereals (including flour, bread, cookies and pasta), sweets (including sugar, chocolate, and candy). The drink category consists of: milk, coffee and tea, soft drinks and alcoholic beverages. The group other nondurables and services includes all other non-durables and services.

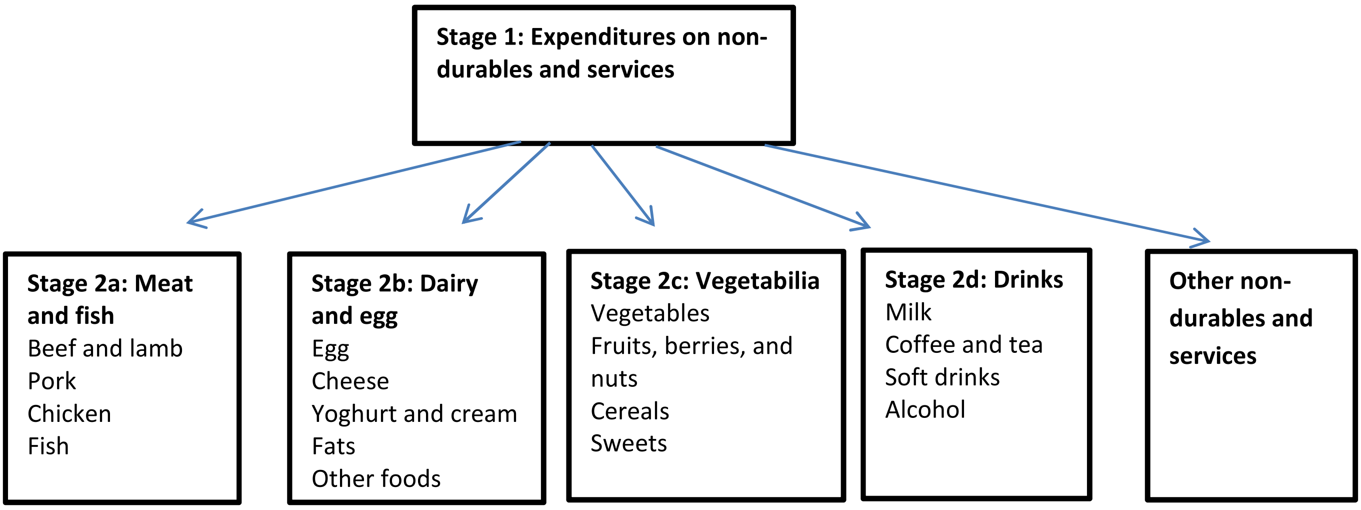

Figure 1. Commodity specification and separability structure

We based our commodity structure on the interests of our partners, what foods we considered to be important substitutes and complements, the structure used by Statistics Norway in their construction of the weights for the Consumer Price Index (CPI), the structure used in previous studies and practical considerations. To estimate the five demand systems labelled as Stages 1, 2a, 2b, 2c, and 2d in Figure 1, we applied the CES data from 1986 to 2012.

To construct the prices, we followed Diewert (1998) and constructed unit values (expenditure divided by quantity) for the goods. For example, for alcohol we first constructed the unit values for beer, wine and spirits. Second, in some time periods all households recorded zero purchases of some goods or there were few purchases with large differences in quality, which resulted in extreme variations in the calculated unit values. To alleviate these problems, we used the imputation method of Cox and Wohlgenant (1986), and constructed quality corrected unit values. Finally, the quality corrected unit values were used to construct household specific Laspeyres price indexes for each of the goods in Stages 1 and 2a-2d. For example, for alcohol the Laspeyres price index for one household was constructed as follows: Let $p_{1,t}$ be the unit value of beer in period t, p_{2t} the unit value of wine, and $p_{3,t}$ the unit value of spirits. Furthermore, let $p_{1,86}$, $p_{2,86}$, $p_{3,86}$, $q_{1,86}$, $q_{2,86}$, $q_{3,86}$ be the average unit values and quantities of beer, wine and spirits in 1986. Then, the Laspeyres price index for one household in period t for alcohol was defined as $p_t = \frac{p_{1,t} \cdot q_{1,86} + p_{2,t} \cdot q_{2,86} + p_{3,t} \cdot q_{3,86}}{p_{1,86} \cdot q_{1,86} + p_{2,86} \cdot q_{2,86} + p_{3,86} \cdot q_{3,86}}$.

The censored two-stage demand system with APC variables

We followed Gustavsen and Rickertsen (2014) and constructed censored systems of demand functions with APC variables. We estimated each of the systems 1 and 2a-2d independently and calculated the conditional price and expenditure elasticities and conditional age and cohorts effects within each system. These age and cohort effects are the percentage differences in purchase between households in a certain age or cohort group and the youngest age or cohort group keeping all other factors constant. As in Gustavsen and Rickertsen

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(2003), we calculated the unconditional price and total expenditure elasticities and the percentage age and cohort effects from the estimated conditional effects.

Following Gustavsen and Rickertsen (2014), we used a linear version of Deaton and Muellbauer's (1980) almost ideal demand system. The expenditure share of good *i* in period *t* for a household, w_{it}, is given as:

$$w_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_{jt} + \beta_i \ln\left(\frac{x_t}{P_t}\right), \tag{1}$$

where p_j denotes the price per unit of good *j*, *x* is the per capita expenditure on the goods included in the system, and *P* is a price index. As discussed in Asche and Wessells (1997), the Törnquist price index can be used. This index is defined by:

$$\ln P_t = \frac{1}{2}\sum_{i=1}^{n}(w_{it} + w_i^0)\ln(p_{it} / p_i^0), \tag{2}$$

where w_i^0 and p_i^0 are the expenditure share and Laspeyres price index of good *i* evaluated at the point of normalization. As recommended in Asche and Wessells (1997), we normalized the index at the mean values for all households and periods.

As in Gustavsen and Rickertsen (2014), we included the APC variables. A cohort is defined by households' heads[2] born in the same five-year period, age groups of the households' heads are defined in five years intervals, and period dummies are defined for each survey year. The age effects show the typical age profile associated with life-cycle changes, the cohort effects are associated with generational effects, and the year effects represent temporary changes in the household's consumption (Deaton 1997). Because of singularity one age *A*, one year *Y*, and one cohort *C* dummy variable had to be dropped and there remain *L*–1 age dummies, and *M*–1 year dummies and *K*–1 cohort dummies *C*. Furthermore, there exists an additional linear relationship across the age, year and cohort dummies. If the year of an observation and the year of birth of the observed cohort are known, then the age of the cohort is known. To solve this problem, one additional year dummy was dropped and the orthogonality restriction $\mathbf{m}'\boldsymbol{\eta} = 0$ was imposed, where $\boldsymbol{\eta}$ is a parameter vector of the year effects and **m** = (1, 2, …, 27) is a trend where *m* = 1 represents the year 1986 and *m* = 27 represents the year 2012. The year dummies were redefined to $Y_m^* = Y_m - [(m-1)Y_2 - (m-2)Y_1]$ for *m* = 3, …, 27. This procedure enforces the restriction $\mathbf{m}'\boldsymbol{\eta} = 0$ so the year effects sum to zero and only reflect cyclical fluctuations.

To take account of seasonality in demand, three quarterly dummy variables, *S*, were specified. In addition, four dummy variables, *R*, representing different household types were included. The reference household is couple with children, and the four dummies represent single-person households, couples without children, single-parent households and other households. The APC decomposition, seasonality and household type were included in the demand system by translating the constant term in Equation (1) to:

$$\alpha_i = \alpha_{i0} + \sum_{k=2}^{16}\delta_{ik}C_k + \sum_{l=2}^{14}\pi_{il}A_l + \sum_{m=3}^{16}\eta_{im}Y_m^* + \sum_{s=2}^{4}\theta_{is}S_s + \sum_{u=2}^{5}\lambda_{iu}R_s. \tag{3}$$

Several households did not purchase all food items. To correct for this censoring, the two-step method of Shonkwiler and Yen (1999) was used. This method yields consistent two-step estimates for a system of equations with limited dependent variables. For example, in applying the first step to Stage 2a, the probabilities of purchasing beef, pork, chicken and fish are estimated by probit models. In the second step, the probability density function $\phi(\mathbf{z}_i'\boldsymbol{\psi}_i)$ for equation *i* and the cumulative density function (cdf) $\Phi(\mathbf{z}_i'\boldsymbol{\psi}_i)$ are used

[2] The head of the household is defined as the household member with the highest income.

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to correct for censoring. Correcting for censoring, inserting Equation (3) into Equation (1) and adding a stochastic error term result in the model:

$$\begin{aligned} w_{it} &= \alpha_{i0}\Phi(\mathbf{z}'_{\mathbf{it}}\boldsymbol{\psi}_{\mathbf{i}}) + \sum_{k=2}^{16}\delta_{ik}\Phi(\mathbf{z}'_{\mathbf{it}}\boldsymbol{\psi}_{\mathbf{i}})C_k + \sum_{l=2}^{14}\pi_{il}\Phi(\mathbf{z}'_{\mathbf{it}}\boldsymbol{\psi}_{\mathbf{i}})A_l + \sum_{m=3}^{16}\eta_{im}\Phi(\mathbf{z}'_{\mathbf{it}}\boldsymbol{\psi}_{\mathbf{i}})Y^{*}_m \\ &+\sum_{s=2}^{4}\theta_{is}\Phi(\mathbf{z}'_{\mathbf{it}}\boldsymbol{\psi}_{\mathbf{i}})S_s + \sum_{u=2}^{5}\lambda_{iu}\Phi(\mathbf{z}'_{\mathbf{it}}\boldsymbol{\psi}_{\mathbf{i}})R_u + \sum_{j=1}^{4}\gamma_{ij}\Phi(\mathbf{z}'_{\mathbf{it}}\boldsymbol{\psi}_{\mathbf{i}})\ln p_{jt} + \beta_i\Phi(\mathbf{z}'_{\mathbf{it}}\boldsymbol{\psi}_{\mathbf{i}})\ln\left(\frac{x_t}{P_t}\right) + \tau_i\phi(\mathbf{z}'_{\mathbf{it}}\boldsymbol{\psi}_{\mathbf{i}}) + u_{it}, \end{aligned} \tag{4}$$

where u_{it} is the error term. The equations in Stage 1 are not censored so for these functions $\Phi(\mathbf{z}'_{\mathbf{t}}\boldsymbol{\psi}) = 1$ and $\phi(\mathbf{z}'_{\mathbf{t}}\boldsymbol{\psi}) = 0$.

Adding up implies the following restrictions:

$$\sum_{i=1}^{4}\alpha_{i0} = 1, \sum_{i=1}^{4}\beta_i = \sum_{i=1}^{4}\tau_i = 0 \text{ and } \sum_{i=1}^{4}\gamma_{ij} = \sum_{i=1}^{4}\delta_{ik} = \sum_{i=1}^{4}\pi_{il} = \sum_{i=1}^{4}\eta_{im} = \sum_{i=1}^{4}\theta_{is} = 0 \ \forall\, j,k,l,m,s. \tag{5}$$

Homogeneity of degree zero in prices and total expenditures and symmetry imply the following restrictions:

$$\sum_{j=1}^{4}\gamma_{ij} = 0 \,\forall\, i \text{ and } \gamma_{ij} = \gamma_{ji} \,\forall\, i,j. \tag{6}$$

The restrictions (5) and (6) are imposed on the system (4).

Following Jonas and Roosen (2008), the total conditional expenditure E_i and uncompensated own-price e_{ij}, and cross-price e_{ij} elasticities were calculated as:

$$\begin{aligned} e_{ii} &= \Phi(\mathbf{z}'_{\mathbf{i}}\boldsymbol{\psi}_{\mathbf{i}})\cdot\left(\gamma_{ii}/w_i - \beta_i\right) - 1, \\ e_{ij} &= \Phi(\mathbf{z}'_{\mathbf{i}}\boldsymbol{\psi}_{\mathbf{i}})\cdot\left((\gamma_{ij} - \beta_i w_j)/w_i\right) \text{ and} \\ E_i &= \Phi(\mathbf{z}'_{\mathbf{i}}\boldsymbol{\psi}_{\mathbf{i}})\cdot\left(\beta_i/w_i\right) + 1. \end{aligned} \tag{7}$$

The elasticities were calculated at the mean values of the expenditure shares.

The conditional percentage cohort effect, i.e., the percentage difference between one cohort group and the youngest cohort group was calculated as:

$$CE_{ik} = \Phi(\mathbf{z}'_{\mathbf{i}}\boldsymbol{\psi}_{\mathbf{i}})\cdot\frac{\delta_{ik}}{w_i}, \tag{8}$$

and the conditional percentage age effect is given by:

$$AE_{il} = \Phi(\mathbf{z}'_{\mathbf{i}}\boldsymbol{\psi}_{\mathbf{i}})\cdot\frac{\pi_{ik}}{w_i} \tag{9}$$

To calculate the unconditional price ue_{ij} and expenditure elasticities UE_i, we corrected for the first-stage effects by using the formulas given in Edgerton (1997) and Carpentier and Guyomard (2001):

$$UE_i = E_i \cdot E_F \tag{10}$$

and

$$ue_{ij} = e_{ij} + w_j\left(\frac{1}{E_j} + e_{FF}\right)E_iE_j + w_jw_FE_FE_i(E_j - 1) \tag{11}$$

where E_i is the conditional expenditure elasticity of good *i* at the second stage, E_F is the food expenditure elasticity at the first stage, e_{ij} is the conditional price elasticity between good *i* and good *j* at the second stage,

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w_j is the expenditure share of good *j* at the second stage, e_{FF} is the own-price elasticity of food at the first stage, and w_F is the expenditure share of food at the first stage.

The unconditional cohort, UCE_{ik}, and age, UAE_{il}, effects were calculated by using a procedure corresponding to the procedure that was used in Gustavsen and Rickertsen (2003) to calculate unconditional effects based on seasonal dummy variables:

$$UCE_{ik} = CE_{ik} + E_i CE_{Fk} \quad (12)$$

$$UAE_{il} = AE_{il} + E_i AE_{Fl} \quad (13)$$

where CE_{Fk} denotes the first-stage conditional cohort effect of food for cohort group *k* and AE_{Fl} denotes the first-stage conditional age effect of food for age group *l*. This procedure was also used in Qian et al. (2018).

Estimation results

The unconditional price and total expenditure elasticities are shown in Table 1. Most of the values of the own-price elasticities are between -0.5 and -1.0. Exceptions are egg (-1.03), sweets (-1.04), milk (-0.09) and alcoholic beverages (-1.12). Most of the cross-price elasticities were around zero, but some were high and negative. For example, the cross-price elasticity between beef and pork was -0.24, which may suggest a correlation rather than a causal effect. The total expenditure elasticities were around 0.5 except for milk (0.22) and alcoholic beverages (1.12).

As discussed above, age and cohort effects are likely to influence future purchases of the foods. Plots of the unconditional age and cohort effects for meat and egg are shown in the Figures 1 and 2. An unconditional age effect shows the expected differences in the purchase of a commodity between one age group and the youngest age group (20 years old) keeping other variables constant. Likewise, an unconditional cohort effect shows the expected percentage difference in the purchase of one commodity between one cohort group and the youngest cohort group keeping other variables constant. The youngest cohort was born between 1983 and 1993, and was included in the surveys for the first time in 2006. The oldest cohort was born between 1908 and 1912, and left the sample in 1994 due to high age.

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	Beef/ lamb	Pork	Chicken	Fish	Egg	Cheese	Yoghurt	Fats	Other foods	Vegetable	Fruits	Cereals	Sweets	Milk	Coffe/ tea	Soft drinks	Alcohol	Other non durables	Expendi- ture
Beef / lamb	-0.92	-0.24	-0.18	-0.04	0.00	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.03	0.05	0.59	0.65
	(0.06)	(0.05)	(0.03)	(0.06)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.14)	(0.03)
Pork	-0.15	-0.92	-0.06	0.09	0.00	0.01	0.01	0.00	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.02	0.04	0.44	0.49
	(0.03)	(0.05)	(0.03)	(0.04)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.02)	(0.03)	(0.11)	(0.02)
Chicken	-0.14	-0.07	-0.82	-0.09	0.00	0.01	0.01	0.00	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.02	0.04	0.48	0.53
	(0.03)	(0.04)	(0.04)	(0.04)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.02)	(0.03)	(0.11)	(0.03)
Fish	-0.02	0.08	-0.12	-0.77	0.00	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.02	0.03	0.35	0.39
	(0.03)	(0.04)	(0.03)	(0.06)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.02)	(0.09)	(0.03)
Egg	0.01	0.01	0.01	0.01	-1.03	0.32	0.09	0.02	0.01	0.02	0.03	0.02	0.02	0.00	0.01	0.03	0.05	-0.03	0.41
	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)	(0.04)	(0.03)	(0.02)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.04)	(0.02)
Cheese	0.01	0.01	0.01	0.01	0.11	-0.81	-0.04	0.03	0.08	0.02	0.03	0.02	0.02	0.00	0.01	0.03	0.06	-0.04	0.44
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.03)	(0.02)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.04)	(0.01)
Yoghurt	0.01	0.01	0.01	0.01	0.04	-0.05	-0.68	0.04	0.04	0.02	0.03	0.02	0.02	0.00	0.01	0.03	0.05	-0.04	0.43
	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)	(0.03)	(0.03)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.04)	(0.01)
Fats	0.01	0.01	0.01	0.01	0.01	0.07	0.06	-0.69	-0.02	0.02	0.02	0.02	0.02	0.00	0.01	0.03	0.05	-0.03	0.39
	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)	(0.03)	(0.02)	(0.02)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.03)	(0.02)
Other foods	0.01	0.01	0.01	0.01	-0.01	0.06	0.02	-0.01	-0.70	0.02	0.03	0.02	0.02	0.00	0.01	0.03	0.06	-0.04	0.43
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.04)	(0.02)
Vegetables	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	-0.70	-0.02	0.00	0.06	0.00	0.01	0.02	0.05	0.03	0.49
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.03)	(0.01)
Fruits	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	-0.02	-0.82	-0.01	0.06	0.00	0.01	0.03	0.06	0.04	0.57
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.03)	(0.01)
Cereals	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	-0.01	-0.72	0.11	0.00	0.01	0.02	0.05	0.03	0.46
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.02)	(0.01)
Sweets	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.02	0.06	0.09	0.18	-1.04	0.00	0.01	0.03	0.05	0.04	0.52
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.02)	(0.00)	(0.00)	(0.00)	(0.01)	(0.03)	(0.01)
Milk	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	-0.09	-0.06	0.10	-0.09	-0.13	0.22
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.04)	(0.01)	(0.02)	(0.04)	(0.02)	(0.01)
Coffe/tea	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.00	0.02	0.02	0.02	0.02	0.02	-0.05	-0.62	0.17	0.20	-0.25	0.42
	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)	(0.02)	(0.02)	(0.03)	(0.04)	(0.02)
Soft drinks	0.01	0.01	0.01	0.01	0.00	0.02	0.01	0.01	0.02	0.02	0.03	0.03	0.02	0.07	0.05	-0.78	0.29	-0.32	0.54
	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.02)	(0.02)	(0.04)	(0.01)
Alcohol	0.01	0.02	0.01	0.02	0.01	0.04	0.02	0.01	0.04	0.04	0.07	0.06	0.04	0.01	0.07	0.27	-1.12	-0.67	1.12
	(0.01)	(0.02)	(0.01)	(0.02)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.03)	(0.05)	(0.09)	(0.02)

Table 1. Unconditional Marshallian price and total expenditure elasticities. Standard errors in the parentheses (calculated from 100 bootstrap repetitions)

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Figure 2 shows that the estimated age effects, relative to the youngest age group, increase for chicken up to about 50 years of age and remains stable until decreasing from about 70 years. The age effect for egg is quite stable over the life cycle, while the age effects for beef and pork are reduced over the life cycle relative to an average twenty year old household. Figure 3 shows that older cohorts eat more beef/lamb, pork and egg than younger cohorts, while younger cohorts eat much more chicken. A decreasing age effect and an increasing cohort effect, as we have for beef and pork, indicates that when younger cohorts replaces older cohorts the total purchases will decrease given constant real total expenditures and prices. For chicken we have the opposite effects, which indicate that when younger cohorts replace older cohorts the total purchases will increase.

Figures 4 and 5 show the estimated age and cohort effects for dairy products. An increasing age effect and an decreasing cohort effect for yoghurt indicate increased per capita purchases as younger cohorts replace older cohorts. For fluid milk, the opposite is true. Increasing cohort effects and decreasing age effects indicate a decrease in future purchases.

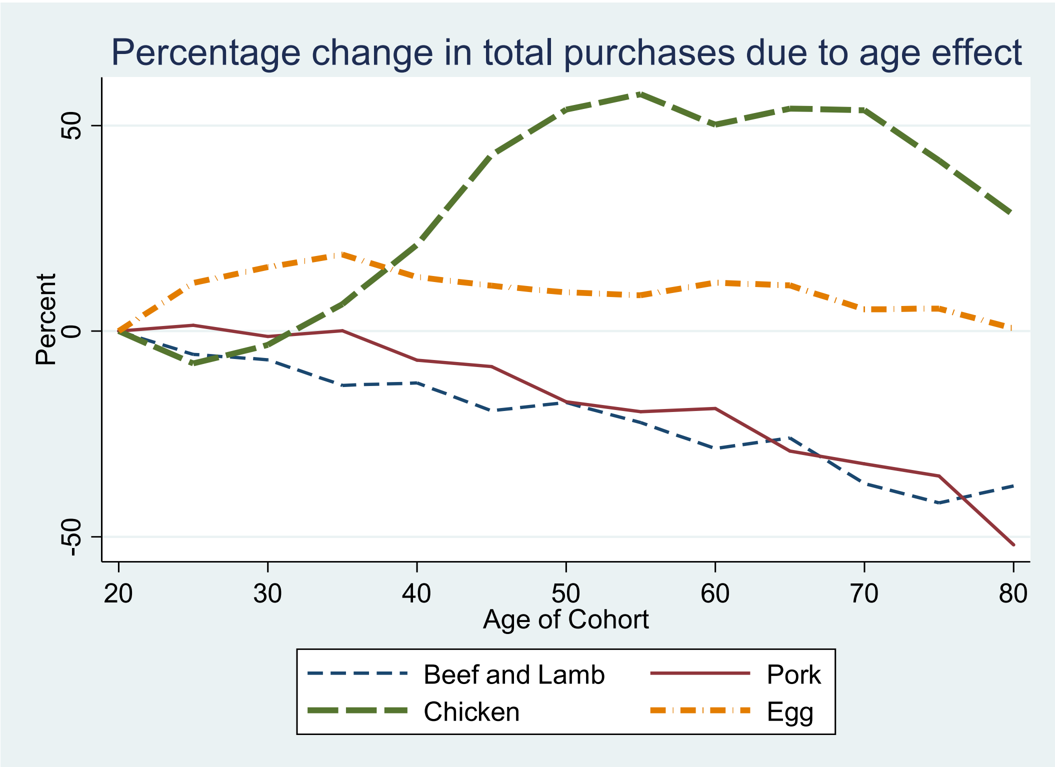

Figure 2. Percentage changes in total purchases of meats and egg relative to a 20 year old household

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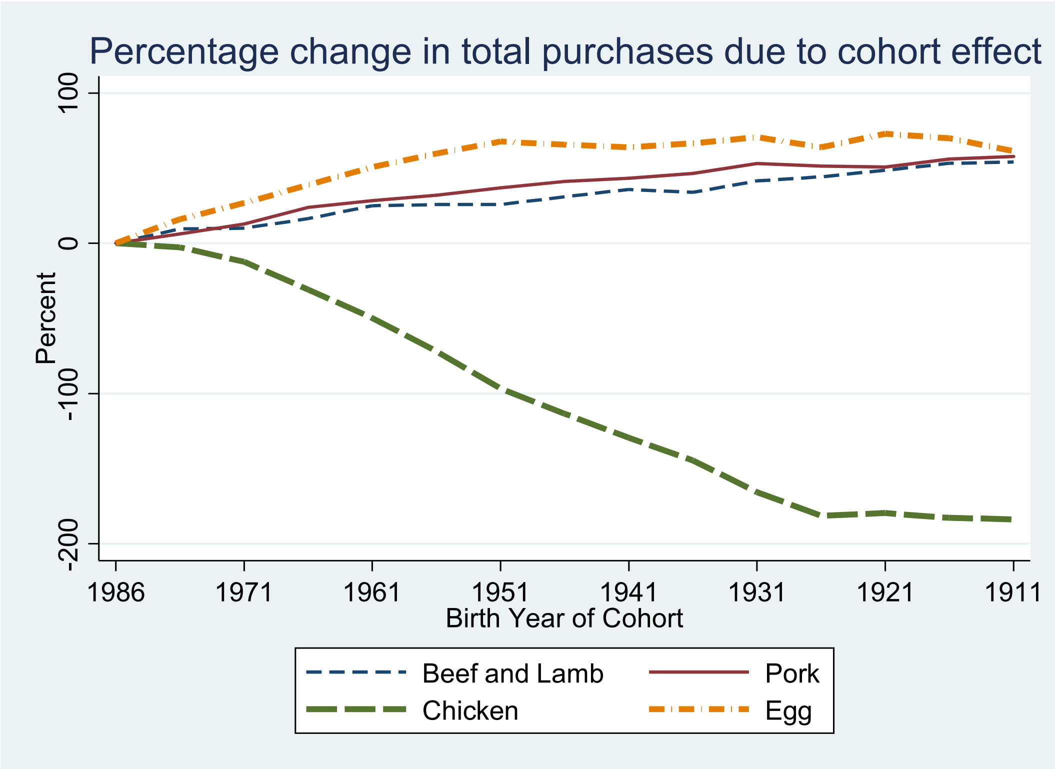

Figure 3. Percentage changes in total purchases of meats and egg relative to the 1983 – 1993 cohort

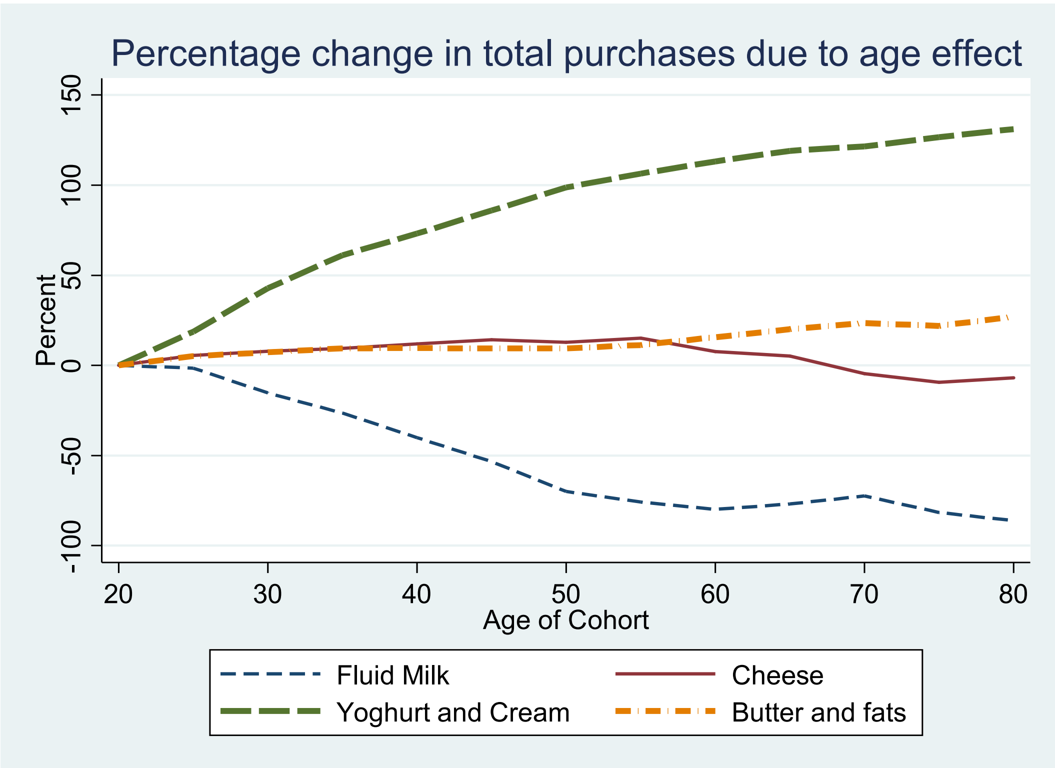

Figure 4. Percentage changes in total purchases of dairy products relative to a 20 year old household

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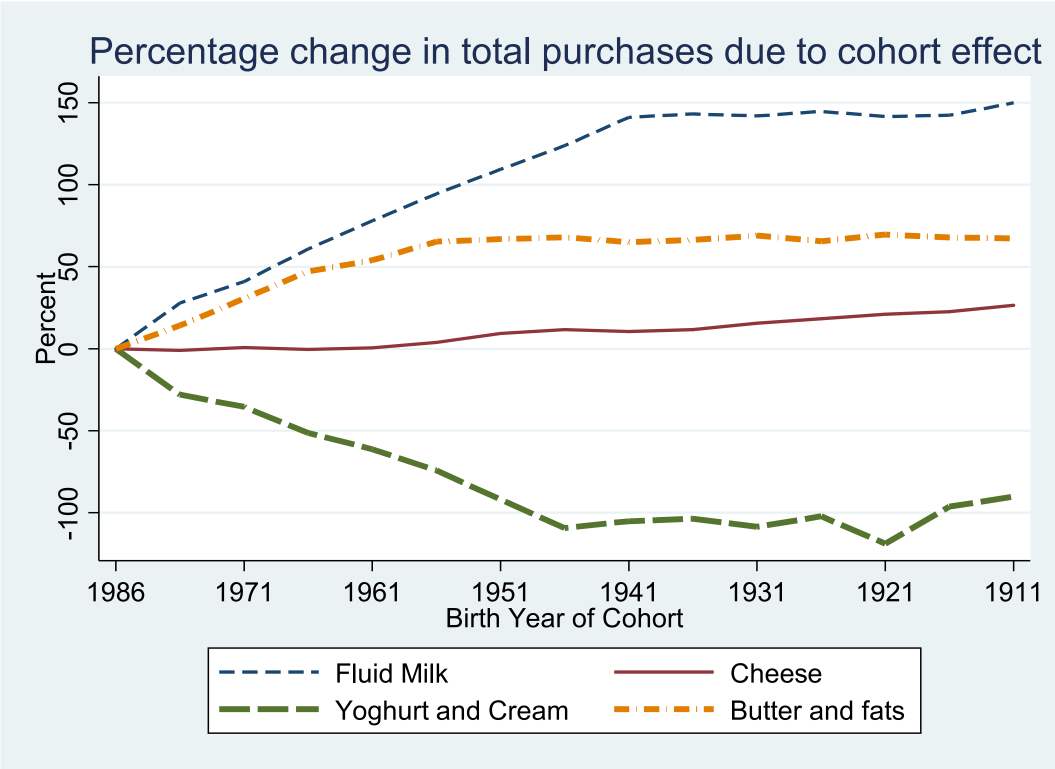

Figure 5. Percentage changes in total purchases of dairy products relative to the 1983 – 1993 cohort

The long-run forecast equations

In our long-run forecasts of meat and dairy products, we assume constant real prices and total expenditures for the period and that all the changes in purchases are due to replacement of older cohorts with younger cohorts while the younger cohorts simultaneously get older. We have household data and have to take account of a changing number of individuals in each household in each age group over time. These changes are reported in Statistics Norway (2016). As a slight simplification, we assume that the average number of individuals in the household within each age group is constant for each of the forecast periods.

For each period, we include households with heads aged between 20 and 80 years at the beginning of the five years forecasting period. In the next period, all the cohorts are five years older and a new cohort, with identical purchases as the twenty years old age group had in the previous period, is included in the forecast. Simultaneously, the cohort that was 80 years old in the previous period will be 85 years old and, therefore, is excluded from the forecast, i.e., the twenty years old cohort has replaced the 85 years old cohort.

The forecasts start with the average observed purchases of each meat and dairy product in each cohort group in 2012, which is the last year in our sample. First, the age effect of each cohort group is used to forecast the purchases when this cohort group has become five years older, i.e., in 2017. Second, each of the forecasts is weighted by the average number of individuals in different households in the age group that the cohort belongs to at the time for all the cohorts aged between 20 and 80 years. This weighted forecast is used to calculate the weighted average purchase for each cohort in 2017. Third, we make a forecast that is adjusted for the expected increases in the population assuming that the new households (mainly immigrants) purchase the same quantities of different products as the rest of the population. Fourth, a new five years forecast is made based on the previous forecast by the procedure above.

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In our multi-period forecasts, we use the unconditional percentage age effects for each of the cohorts in Equation (13). The percentage age effect on the purchase q of good for a household in age group l is given by:

$$UAE_l = \frac{q_l - q_{20}}{q_{20}} \Rightarrow q_l = UAE_l \cdot q_{20} + q_{20}, \tag{14}$$

where q_{20} is the quantity purchased by the households in the age group 20 years old. This implies that the age effect for a household in a certain cohort group in two different 5-years periods l and (l-5) is given by:

$$UAE_l^* = \frac{UAE_l - UAE_{l-5}}{UAE_{l-5} + 1}. \tag{15}$$

A household who was between 18 and 22 years (on average 20 years) old in 2012 was born between 1990 and 1994 (on average 1992). This cohort was registered with average purchase of a good of q_{12}. Five years later, in 2017, the expected purchase of a household in this cohort will be $q_{92\_17} = (1+UAE_{25}^*)\cdot q_{92\_12}$. Ten years later, in 2022, the expected purchase of a household in the 1992 cohort is $q_{92\_22} = (1+UAE_{25}^*)\cdot(1+UAE_{30}^*)\cdot q_{92\_12}$. Fifteen years later, in 2027, the expected purchase of a household in the 1992 cohort (who is now 35 years old) will be $q_{92\_27} = (1+UAE_{25}^*)\cdot(1+UAE_{30}^*)\cdot(1+UAE_{35}^*)\cdot q_{92\_12}$. The forecasts for the other cohorts are made in a corresponding way.

Forecasts of meat and dairy purchases

In Table 2, the forecasts for beef, pork, chicken, egg, milk, cheese, yoghurt and fats are shown for 2017, 2022 and 2027. The second column shows the average per capita recorded purchases in kilograms in 2012. The next three columns show the forecasts for 2017. In the third column, the forecasts in kilograms per capita for 2017 are shown. In the fourth column, the percentage differences between these forecasts and the observed per capita purchases in 2012 are shown. In the fifth column, the percentage differences adjusted for the predicted population growth are shown. In the next three columns, corresponding forecasts for 2022 are shown, and in the last three columns, the forecasts for 2027 are shown. One hundred iterations from non-parametric bootstraps were used to calculate the standard deviations reported in the parentheses in the table.

	2012	2017			2022			2027		
	Kg/cap[a]	Kg/cap[b]	Δ%/cap[c]	Δ%[d]	Kg/cap[b]	Δ%/cap[c]	Δ%[d]	Kg/cap[b]	Δ%/cap[c]	Δ%[d]
Beef and lamb	7.44	6.58	-11.63	-6.66	5.54	-25.55	-18.05	5.24	-29.59	-19.22
		(0.14)[e]	(1.83)	(1.93)	(0.18)	(2.48)	(2.73)	(0.27)	(3.63)	(4.16)
Pork	17.60	15.40	-12.52	-7.60	13.60	-22.72	-14.92	11.71	-33.48	-23.69
		(0.23)	(1.30)	(1.37)	(0.34)	(1.92)	(2.11)	(0.38)	(2.18)	(2.50)
Chicken	7.43	7.93	6.73	12.73	8.46	13.90	25.38	8.91	20.01	37.67
		(0.11)	(1.50)	(1.58)	(0.23)	(3.15)	(3.47)	(0.36)	(4.87)	(5.58)
Egg	12.20	11.48	-5.89	-0.60	11.01	-9.77	-0.68	10.29	-15.65	-3.23
		(0.08)	(0.63)	(0.67)	(0.14)	(1.15)	(1.27)	(0.20)	(1.64)	(1.88)
Milk	70.17	58.41	-16.75	-12.08	48.89	-30.33	-23.31	41.36	-41.05	-32.37
		(2.24)	(3.19)	(3.37)	(2.53)	(3.60)	(3.96)	(3.22)	(4.58)	(5.26)
Cheese	14.78	14.55	-1.59	3.94	14.39	-2.63	7.18	14.40	-2.57	11.77
		(0.07)	(0.47)	(0.49)	(0.13)	(0.85)	(0.93)	(0.18)	(1.24)	(1.43)

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Yoghurt	23.81	24.23	1.77	7.49	25.97	9.09	20.09	28.19	18.42	35.85
		(0.06)	(0.24)	(0.26)	(0.13)	(0.56)	(0.61)	(0.26)	(1.08)	(1.24)
Fats	11.98	11.54	-3.61	1.81	10.70	-10.69	-1.69	10.13	-15.40	-2.94
		(0.06)	(0.50)	(0.53)	(0.08)	(0.64)	(0.72)	(0.11)	(0.89)	(1.02)

Table 2. Per capita purchases in 2012 and the predicted purchases in 2017, 2022 and 2027

Notes: [a] Observed per capita purchases in 2012 from the Consumer Expenditure Survey of Statistics Norway.

[b] Predicted per capita purchases.

[c] The percentage differences between the predicted per capita purchases in the year and the observed purchases in 2012.

[d] The percentage difference between the predicted purchases and the observed purchases in 2012 adjusted for the predicted population growth.

[e] Standard deviations from 100 bootstraps.

The per capita purchases of beef and lamb are forecasted to decrease by almost 30 percent from 2012 to 2027. Adjusted for the expected population increase, the purchases are predicted to be 19 percent lower in 2027 than in 2012. The per capita pork purchases are expected to decrease with 33 percent between 2012 and 2027. Adjusted for population growth, the pork purchases are expected to decrease by 24 percent. The per capita chicken purchases are expected to increase by 20 percent. Adjusted for population growth, the total purchases are expected to increase by 38 percent. The per capita purchases of eggs are expected to decrease by 16 percent. Adjusted for population growth, the total purchases are expected to decrease by 3 percent. The per capita milk purchases are expected to be reduced by 41 percent. Adjusted for population growth, the total purchases are expected to be reduced by 32 percent. The per capita cheese purchases are expected to be reduced by 3 percent. Adjusted for population growth, the total purchases are expected to increase by 12 percent. The per capita yoghurt purchases are expected to increase by 18 percent. Adjusted for population growth, the total purchases are expected to increase by 36 percent. The per capita purchases of fats are expected to be reduced by 15 percent. Adjusted for population growth, the total purchases are expected to be reduced by 3 percent.

Summary

In this paper, we have constructed a two-step censored food demand model including all the food commodities in the Norwegian household CES. We used data from 1986 to 2012 to estimate five weakly separable demand systems. The unconditional price and expenditure elasticities and age and cohort effects were constructed from the estimated conditional elasticities. The age effects for each cohort group were used to make per capita purchase forecasts for eight different meat and dairy products for 2017, 2022 and 2027. To make aggregate forecasts of purchases, the predicted purchases for each age group were weighted with the expected number of households and adjusted for expected population growth. The forecasts for 2027 show a decrease in the purchases of beef and lamb, pork and milk. The purchases of chicken, cheese and yoghurt are expected to increase, while the purchases of eggs and fats are not expected to change very much.

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