European Dairy Industry Model

DEMAND FOR DAIRY PRODUCTS IN THE EUROPEAN UNION

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Demand for dairy products in the European Union

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Abstract

The objective of this project is to develop complementary modelling tools able to simulate the impact of alternative policy scenarios for the dairy sector over the medium term. Because the analysis of the European Union (EU) dairy policy in the future strongly depends on the evolution of the demand for dairy products and on the elasticity of demand, we have developed a specific analysis to study demand for dairy products in the European Union.

We focus on two issues relative to the European Union demand for dairy products. First, we present estimates of the autonomous trend in consumption of dairy products in the fifteen EU member countries. Second, we estimate demand price and expenditures elasticities for dairy products in France and for Italy.

Keywords: demand, dairy, trend, elasticity, AIDS.

1. Introduction

This study is part of the European Dairy Industry Model (EDIM) project. The objective of this project is to develop complementary modelling tools able to simulate the impact of alternative policy scenarios for the dairy sector over the medium term. A EU dairy sector model has been developed by Bouamra et al. (2002). It integrates the whole channel of the EU dairy industry from the supply of milk to the demand for final commodities through an intermediate step of processing milk into final commodities. It is an hedonic (milk characteristics), spatial equilibrium model which integrates an agricultural product (cow milk), 2 milk components (fat and protein), the different member states (14) and the rest of the world, and 14 final dairy products. The model integrates the EU dairy policy instruments that include milk production quota, intervention prices as for butter and SMP, domestic subsidies for industrial uses of butter and SMP, a production subsidy for casein, export subsidies and import tariff rate quotas for each final dairy product as well as direct payments. Finally, GATT import and export commitments are explicitly modelled.

Simulation results from this model are very sensitive to the evolution of domestic demand. Because, aggregate demand for dairy products is rather inelastic, any change in aggregate demand generates large price effects (given that supply is fixed due to milk quota). It is thus
very important to precisely analyze how demand for the different dairy products is likely to change in the future. The view behind this analysis is that annual consumption of a product depends on prices and on other factors such as income, population growth, food habits or health concerns. In the following study, we focus our attention on the impact of these non-price factors that affect consumption.

Because in the existing model assumptions on price elasticity of demand for dairy products comes from various studies, we also estimate a demand system for dairy products in France and Italy. We use an AIDS model of multi-stage budgeting allocation. Using the results we compute conditional and unconditional elasticities for the different dairy products.

2. Methodology

2.1 Estimation of consumption trends

We estimate the autonomous change in consumption, that is excluding the changes in consumption that are due to price changes. We first correct the observed data from variations that are due to price changes. We thus calculate the theoretical consumption of every past year assuming that the price of the product is the price observed in a given year. We use the following expression to determine the adjusted consumption:

$$ C_{tc} = C_t \left[ 1 + \varepsilon_D \frac{P_{ref} - P_t}{P_t} \right] $$

(1)

with $C_{tc}$ the adjusted consumption for year $t$, $C_t$ the observed consumption for year $t$, $P_t$ and $P_{ref}$ the price for the period $t$ and the reference period, $\varepsilon_D$ the price elasticity of demand.

Then, using these adjusted consumption data, we estimate a consumption trend function that depends on the following possible explanatory variables: time, GDP, population. Several forms of econometric or statistical models are used. The functional forms used in this study are the following:

- Linear regression. We estimate various linear regressions (using the variables or the logarithm of variables, including or not squares of the independent variables).
- Linear regression using a Box-Cox transformation of the explained variable:

$$ C_t^\lambda = \left[ \frac{C_t^\lambda - 1}{\lambda} \right] = \sum a_i x_{i,t} + \varepsilon_t $$

(2)

- Models in differences, that is explaining the difference of the explained variable $\Delta C_t$ by the differences of explanatory variables:

$$ \Delta C_t = \sum a_i \Delta x_{i,t} + b + \varepsilon_t $$

(3)

with $\Delta C_t = C_t - C_{t-1}$

and $\Delta x_{i,t} = x_{i,t} - x_{i,(t-1)}$ for $i = 1, \ldots, n$
In the second step, we check the validity of models (validity of the estimated models is judged by checking residual properties, model significance and significance of explanatory variables). To choose among the valid models, we use two selection criteria: the adjusted R² and the mean squared error of the predictor.

2.1 Estimation of price elasticity of demand

As it is now very common, we used the Almost Ideal Demand System (Deaton and Muellbauer, 1980).

The general specification of the AIDS model is:

\[
\sum_{j=1}^{n} w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_j + \beta_i \log(Y / P)
\]

(4)

where:

- \( w_i \) is the budget share of the \( i^{th} \) good,
- \( \alpha_i \) is the constant coefficient in the \( i^{th} \) share equation,
- \( \gamma_{ij} \) is the slope coefficient associated with the \( j^{th} \) good in the \( i^{th} \) share equation,
- \( p_j \) is the price of the \( j^{th} \) good,
- \( Y \) is the total expenditure for goods.
- \( P \) is a general price index. It is defined by:

\[
\log P = \alpha_0 + \sum_{i=1}^{n} \alpha_i \log p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \log p_i \log p_j
\]

(5)

As commonly used in empirical work, \( P \) is replaced by the Stone price index (\( P^* \)). However, this index does not satisfy the properties of index numbers since it varies with changes in the unit of measurement of prices. As Moschini (1995) suggests, this problem can be solved by using a ‘corrected’ Stone index defined as

\[
\log(P^*) = \sum_{i=1}^{n} w_i \log \left( \frac{P_i}{P_{i0}} \right)
\]

(6)

where \( P_{i0} \) is a base period mean value for the \( i^{th} \) product. Hence, scaling prices by their means is a practical solution to solve the problem of the units of measurement. We use this method in the empirical application.

Moreover, the model is taken in differences, with a term for the trend effect:

\[
\Delta w_i = \alpha_i + \sum_{j} \gamma_{ij} \Delta \log(p_j) + \beta_i \Delta \log(Y / P) + \eta \Delta \log(\text{year}) \quad j=1,...,n
\]

(7)

Theoretical restrictions are imposed: adding-up, homogeneity, symmetry, and negativity. Concavity was locally imposed using a semiflexible approach of the Cholesky decomposition as proposed by Moschini (1998).

For France, we estimate an AIDS model for each step of a four-stage budgeting allocation (see Figure 1). In the first stage, consumer chooses between food and non food expenses.
Then, among food expenses, he chooses between dairy products (except butter), fat products, meat and others. Because butter directly competes with other fat products, we designed a ‘fat’ product category. Moreover, in order to analyse the impact of demand for meat on demands for dairy product, we specify a meat aggregate. Then in a third stage, we focus on the one hand on the fat system and on the other hand on the dairy products. Finally, in a fourth stage, because there are a lot of different cheeses in France, we focus on the demand for cheese.

Figure 1: Utility tree used to estimate a demand system for dairy products in France

For Italy, we use a simplified utility tree (Figure 2). A three-stage budgeting allocation is defined as cheese consumption is not detailed as it was for France. However, the general ideas for decomposition are similar except the choice for butter consumption. Here, butter is assumed to compete directly with other dairy products.

Figure 2 - Utility tree used to estimate a demand system for dairy products in Italy
3. Data

3.1 Data used to compute estimates and projections of consumption

We use annual data from Eurostat, CNIEL (Centre National Interprofessionnel de l’Economie Laitière, France) and ZMP (Zentrale Markt- und PreisberichtstelleZentrale Markt- und Preisberichtstelle) for total human consumption (household consumption + industrial consumption) by country. We used UNEP (United Nations Environnemental Program) data and Eurostat data for Gross Domestic Product (GDP), data from the European Council for population. We use price data from INSEE (Institut National de la Statistique et des Etudes Economiques, France), ZMP, UNICATT (Universita Cattolica del Sacro Cuore, Italy), FAL (Bundesforschungsanstalt für Landwirtschaft, Germany ) and UK statistics. When possible, data cover the period 1960-2002.

To compute forecasts of consumption, we assume various growth rates of GDP. In this paper, we present the results of consumption forecasting for a GDP growth rate equal to 1% per year from 2004 to 2010. For population, we use forecasts computed by United Nations and Eurostat (available for each country).

3.2 Data used to compute elasticity estimates.

For France, we use data about quantities and values of dairy products purchased in France from INSEE (for the 1st, 2nd and the fat products 3rd stage) and SECODIP (for the dairy products 3rd stage and for the 4th stage). Data from INSEE are annual data and cover the period 1960-2003. Data from SECODIP are four-week period and cover the period 1996-2004.

For Italy, we use data from National Accounting Data from ISTAT (for the first and second stages) and retail data from NIELSEN (for the 3rd stage). Data cover respectively the periods 1952-2002 (annual data) and 1991-2003 (by semester).

4. Results

4.1 Estimates of consumption trends

The EU dairy model that was developed considers 14 different dairy products (butter, fluid milk, soft cheese, hard cheese, semi-hard cheese, processed cheese, blue cheese, fresh cheese, cream, fresh dairy products, whole milk powder, skimmed milk powder, condensed milk and casein). When possible, that is when time series data are available at this level of disaggregation, we estimate consumption trends for each of the 13 final consumption dairy products (all except casein). Moreover, because the model represents the dairy industry in each EU member states, we also estimate trends at the EU member state level. More precisely, we estimate trends for the 4 main dairy consumer countries (Germany, France, Italy and the United Kingdom) and for the group of the other 11 EU member countries.

In table 1, we provide the main results. We provide results for three countries plus the trend calculated at the EU-15 level. EU-15 trend is calculated using the trends estimated for the different member states. It is interesting to note that butter and fluid milk consumption are likely to decrease at the EU-15 level. On the contrary, the demand for the other dairy products is likely to increase. Some increases in consumption are rather high (cheese, fresh dairy products). These reflect past evolution. Obviously, it is questionable to know whether past
trends will continue. However, the estimated models always integrate the possibility of slow down in the consumption (for example using polynomial expressions). It should also be stressed that these results correspond to the total consumption of dairy products. That is the direct consumption from consumers at home and outside home plus the indirect consumption via the agro-food system.

Table 1: Estimated annual average growth rate of dairy product consumption between 2000 and 2010

<table>
<thead>
<tr>
<th>Product</th>
<th>EU-15</th>
<th>Germany</th>
<th>France</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butter</td>
<td>-1.4%</td>
<td>-1.8%</td>
<td>-0.4%</td>
<td>+0.7%</td>
</tr>
<tr>
<td>Cheese</td>
<td>+1.7%</td>
<td>+1.4%</td>
<td>+0.7%</td>
<td>+1.2%</td>
</tr>
<tr>
<td>Processed cheese</td>
<td>+1.4%</td>
<td>+0.4%</td>
<td>+1.9%</td>
<td>+1.5%</td>
</tr>
<tr>
<td>Fluid milk</td>
<td>-0.6%</td>
<td>-1.1%</td>
<td>-0.2%</td>
<td>-1.4%</td>
</tr>
<tr>
<td>Cream</td>
<td>+1.3%</td>
<td>+0.1%</td>
<td>+2.1%</td>
<td>+2.1%</td>
</tr>
<tr>
<td>Fresh dairy products</td>
<td>+2.4%</td>
<td>+1.0%</td>
<td>+2.3%</td>
<td>+3.7%</td>
</tr>
</tbody>
</table>

Cheese = all kinds of cheese except processed cheese

With respect to milk powders and condensed milk, consumptions greatly vary from year to year and it is difficult to estimate trends. We estimate that the annual average growth rate of consumption for whole milk powder is +1.7%. For condensed milk, it is +2.3%. For skimmed milk powder, it was not possible to estimate a trend as the evolution of consumption is not explained by any of the variables we have. It seems that skim milk powder can be substituted by whey powder and thus the consumption highly depends on the relative price between these two products.

Given these different trends of consumption, using the composition of the different products in fat and protein, we compute an estimated annual average growth rate of fat and protein consumption. We find that both fat and protein consumption will increase. It is estimated that EU consumption of fat (from milk) will increase by 0.5% a year and that EU consumption of protein (from milk) will increase by 1.1% a year.

4.2 Estimates of price demand elasticities

In the following, we report our main findings with respect to own and cross price elasticities of dairy products in France and Italy. We computed both the conditional and the unconditional uncompensated elasticities.

The several stage budgeting allocation implies weak separability of consumer preferences. The practical implication of this assumption is that estimation is more simple and parsimonious in degree of freedom: in fact, each step can be estimated independently. However, the elasticities directly estimated using demand systems are conditional to the assumed separability tree and therefore to the assigned group of expenditure. Whether conditional or unconditional elasticities should be more relevant depends on the specific objective of the empirical application. For the policy objectives of the EDIM project, unconditional elasticities are more relevant since they better measure the detailed reaction of dairy consumption to a change in macroeconomic variables such as GDP and policy measures. Therefore, to compute unconditional elasticities from the conditional counterpart we adopted the method suggested by Edgerton (1997).
In Tables 2 and 3, we present the conditional and unconditional uncompensated price elasticities of dairy products. Unconditional elasticities are lower than conditional ones. All expenditures elasticities are highly significant and of the same order of magnitude (around 0.6). Own price elasticities are generally significant (except for cream) and as it is frequently found in the literature demand for dairy products is inelastic. However, we found a larger value for the demand for fluid milk. This result was not expected as it is generally thought that demand for fluid milk is very inelastic. Only a small number of cross price elasticities are significant. With respect to unconditional elasticities, only one cross-price relation is significant: the one between cheese and cream which reveals a complementarity between these two products.

Table 2: Conditional uncompensated elasticities for dairy products

<table>
<thead>
<tr>
<th>Product</th>
<th>Fresh Products</th>
<th>Cream</th>
<th>Cheese</th>
<th>Fluid Milk</th>
<th>Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Products</td>
<td>-0.615***</td>
<td>-0.007</td>
<td>-0.231*</td>
<td>-0.076</td>
<td>0.928***</td>
</tr>
<tr>
<td>Cream</td>
<td>-0.063</td>
<td>-0.078</td>
<td>-0.692***</td>
<td>-0.113</td>
<td>0.946***</td>
</tr>
<tr>
<td>Cheese</td>
<td>-0.226**</td>
<td>-0.070***</td>
<td>-0.674***</td>
<td>-0.081</td>
<td>1.051***</td>
</tr>
<tr>
<td>Fluid Milk</td>
<td>-0.190</td>
<td>-0.031</td>
<td>-0.201</td>
<td>-1.005***</td>
<td>1.027***</td>
</tr>
</tbody>
</table>

Table 3: Unconditional uncompensated elasticities for dairy products

<table>
<thead>
<tr>
<th>Product</th>
<th>Fresh Products</th>
<th>Cream</th>
<th>Cheese</th>
<th>Fluid Milk</th>
<th>Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Products</td>
<td>-0.348**</td>
<td>0.025</td>
<td>0.106</td>
<td>0.055</td>
<td>0.561***</td>
</tr>
<tr>
<td>Cream</td>
<td>0.209</td>
<td>-0.046</td>
<td>-0.348*</td>
<td>0.019</td>
<td>0.572***</td>
</tr>
<tr>
<td>Cheese</td>
<td>0.077</td>
<td>-0.034*</td>
<td>-0.292**</td>
<td>0.066</td>
<td>0.635***</td>
</tr>
<tr>
<td>Fluid Milk</td>
<td>0.106</td>
<td>0.004</td>
<td>0.173</td>
<td>-0.861***</td>
<td>0.620***</td>
</tr>
</tbody>
</table>

Table 4: Unconditional uncompensated elasticities for fat products

<table>
<thead>
<tr>
<th>Product</th>
<th>Butter</th>
<th>Oils&amp;Margarine</th>
<th>Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butter</td>
<td>-0.202*</td>
<td>-0.057</td>
<td>0.709***</td>
</tr>
<tr>
<td>Oils&amp;Margarine</td>
<td>-0.027</td>
<td>-0.144**</td>
<td>0.466***</td>
</tr>
</tbody>
</table>

Finally, Table 5 provides the results for cheese which are derived from the fourth stage. Again, expenditure elasticities are highly significant and vary between 0.43 and 0.75. Own price elasticities are all negative and they are high (in absolute term) for some cheese. We also find some substitutability between the different cheese categories (soft cheese and semi-hard cheese, fresh cheese and hard cheese, processed cheese and hard cheese).
Table 5: Unconditional uncompensated elasticities for the different cheese categories

<table>
<thead>
<tr>
<th>Product</th>
<th>Soft</th>
<th>Hard</th>
<th>Semi-Hard</th>
<th>Blue</th>
<th>Fresh</th>
<th>Processed</th>
<th>Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft</td>
<td>0.586***</td>
<td>-0.084</td>
<td>0.363***</td>
<td>0.029</td>
<td>0.005</td>
<td>0.008</td>
<td>0.578***</td>
</tr>
<tr>
<td>Hard</td>
<td>-0.105</td>
<td>-0.393***</td>
<td>0.118</td>
<td>-0.051</td>
<td>0.139**</td>
<td>0.139***</td>
<td>0.688***</td>
</tr>
<tr>
<td>Semi-Hard</td>
<td>0.527***</td>
<td>0.161</td>
<td>-1.196***</td>
<td>0.118</td>
<td>0.094</td>
<td>-0.042</td>
<td>0.736***</td>
</tr>
<tr>
<td>Blue</td>
<td>0.099</td>
<td>-0.215</td>
<td>0.333</td>
<td>-1.074***</td>
<td>0.137</td>
<td>0.373**</td>
<td>0.752***</td>
</tr>
<tr>
<td>Fresh</td>
<td>0.034</td>
<td>0.500**</td>
<td>0.250</td>
<td>0.124</td>
<td>-0.986***</td>
<td>-0.132</td>
<td>0.456***</td>
</tr>
<tr>
<td>Processed</td>
<td>0.065</td>
<td>0.736***</td>
<td>-0.123</td>
<td>0.478**</td>
<td>-0.197</td>
<td>-0.332**</td>
<td>0.428***</td>
</tr>
</tbody>
</table>

*** significant at 1%, ** significant at 5%, * significant at 10%

Italy

In Tables 6 and 7, we present the conditional and unconditional uncompensated price elasticities for dairy products in Italy.

Table 6: Conditional uncompensated elasticities for dairy products in Italy

<table>
<thead>
<tr>
<th></th>
<th>Liquid milk</th>
<th>Fresh dairy</th>
<th>PDO cheese</th>
<th>Other cheese</th>
<th>Butter</th>
<th>EXP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid milk</td>
<td>-0.825***</td>
<td>0.226</td>
<td>-0.236***</td>
<td>-0.245***</td>
<td>0.205**</td>
<td>0.874***</td>
</tr>
<tr>
<td>Fresh dairy</td>
<td>0.228</td>
<td>-1.086***</td>
<td>-0.365***</td>
<td>0.451</td>
<td>-0.263***</td>
<td>1.036***</td>
</tr>
<tr>
<td>PDO cheese</td>
<td>-0.164***</td>
<td>-0.176***</td>
<td>-0.433***</td>
<td>-0.364***</td>
<td>-0.067***</td>
<td>1.204***</td>
</tr>
<tr>
<td>Other cheese</td>
<td>-0.129***</td>
<td>0.257</td>
<td>-0.305***</td>
<td>-0.626***</td>
<td>-0.015</td>
<td>0.819***</td>
</tr>
<tr>
<td>Butter</td>
<td>0.595***</td>
<td>-0.674***</td>
<td>-0.327***</td>
<td>-0.115</td>
<td>-0.417***</td>
<td>0.938***</td>
</tr>
</tbody>
</table>

Table 7: Unconditional uncompensated elasticities for dairy products in Italy

<table>
<thead>
<tr>
<th></th>
<th>Liquid milk</th>
<th>Fresh dairy</th>
<th>PDO cheese</th>
<th>Other cheese</th>
<th>Butter</th>
<th>EXP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid milk</td>
<td>-0.718***</td>
<td>0.355</td>
<td>-0.016</td>
<td>-0.029</td>
<td>0.71***</td>
<td>0.628***</td>
</tr>
<tr>
<td>Fresh dairy</td>
<td>0.321</td>
<td>-0.974***</td>
<td>-0.045***</td>
<td>0.347***</td>
<td>-0.572**</td>
<td>0.744***</td>
</tr>
<tr>
<td>PDO cheese</td>
<td>-0.007</td>
<td>-0.094</td>
<td>-0.118***</td>
<td>-0.091</td>
<td>-0.081</td>
<td>0.865***</td>
</tr>
<tr>
<td>Other cheese</td>
<td>-0.055</td>
<td>0.675***</td>
<td>-0.103</td>
<td>-0.448***</td>
<td>0.089</td>
<td>0.588***</td>
</tr>
<tr>
<td>Butter</td>
<td>0.242***</td>
<td>-0.22***</td>
<td>-0.016</td>
<td>0.019</td>
<td>-0.378***</td>
<td>0.674***</td>
</tr>
</tbody>
</table>

As in the case of France, the absolute value of the direct price elasticity for liquid milk is high compared to a priori expectations. Quite inelastic appear to be the price elasticity for PDO cheeses that also show the highest total expenditure elasticity. Among the other results, more investigation is needed to explain the relatively high substitutability between liquid milk and butter. Finally, expenditure elasticities are of the same order of magnitude as compared to the results for France.

5. Conclusions

Since the results of the dairy model, that aims at analyzing the impact of the CAP reform, are very sensitive to the assumptions on demand trend and since trends may be different among EU member countries, it was important to estimate these demand trends. According to these estimates, consumption trends of dairy products are different according to the product considered. Consumption of basic products such as butter and fluid milk will decrease.
whereas products such as cheese and fresh dairy products will increase. On the whole, it is expected that demand for protein increases more than the demand for fat in the future.

Since the results of any analysis of dairy policy reforms depend on the assumptions on price elasticity of dairy products, we estimate a demand system in France and Italy. We generally find that demand is rather price inelastic and that expenditure elasticities are significant and vary between 0.4 and 0.7. However, the absolute value of price elasticities is sometime higher than expected. It is specially the case for the demand for fluid milk both in France and Italy. For France, we also show that aggregate demand for cheese is relatively price inelastic. However, the demand of a specific cheese is more price elastic as substitution between cheese is frequently significant.

6. Reference list


