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AKF

2001

Paper for the 11th annual EAERE Conference, Southampton, June 2001

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Abstract: We analyse the consumption of organic foods in Denmark in the late 1990s. The aim of our study is to identify the influence of price premiums on buying propensity. The methodological approach is econometric estimation based on four-weekly observations of purchases of organic and conventional dairy products. We apply the AIDS demand system and estimate dynamic as well as static specifications, homothetic as well as non-homothetic specifications, and furthermore specifications with and without trends. The preferred model is a homothetic, static model with a linear trend. The price elasticities estimated in our study are higher than those estimated in other studies on food demand. In the end of the paper, we outline our current research on organic foods.

1. Introduction

Modern agriculture in the industrialised countries is highly effective and intensive. However, this efficiency comes at a cost of environmental degradation. In particular, the environmental problems are caused by nitrate and pesticides in drinking water, residuals of pesticides and medicine in foods, eutrophication of marine and fresh water, and eutrophication and acidification of terrestrial ecosystems. For these problems, agricultural production carries the main responsibility and organic farming may offer a solution to some of these problems. However, a major conversion of conventional agriculture to organic agriculture will depend on several conditions – first and foremost that the consumers are interested in organic foods, and second that they are willing to pay price premiums for these goods.

Demand for organic foods has increased notably in Denmark as well as in other industrialised countries in the past decade. Nevertheless, the organic consumption constitutes only a few percent of the total food consumption in most countries. Today, organic foods occupy a marginal position, but they may reach considerable market shares in the future. In this paper, the importance of price premiums for a potential market expansion is analysed. The Danish market is especially well suited for these types of analyses, because the Danish market for organic foods is relatively mature and does not suffer seriously from the imperfections and barriers, which dominate most of the markets outside Denmark. This is partly because organic foods are sold through conventional retail stores (mainly supermarkets) and are supplied where most of the consumers do their shopping, and partly because the supply – compared to most other countries – is relatively stable. Finally, Denmark has a very well functioning labelling and certification program, which the consumers in general know of and trust (Wier and Calverley, 1999).

Altogether, these factors have made the Danish per capita consumption of organic foods probably the highest in the world. In many ways, the Danish market provides insights about future markets in other countries.

2. Market development

Table 1 shows the budget shares (i.e. the organic part of the consumption relative to the total consumption, measured in values) together with the growth in these budget shares for dairy products. Dairy products have higher market shares than any other food type; In comparison, organic bread and cereals, and fruit and vegetables occupies around 4 per cent only, while organic meat products occupy a marginal position with a share on approximately 1%.

Table 1. The 5 most established organic dairy products 1997-1998

	Budget share (%)	***Annual growth in budget share (%)***
Milk	21	33
Eggs	20	28
Butter	18	27
Yoghurt	11	21
Cheese	5	40
All dairy products	**10**	**26**

3. Data

The data used in our study provided by a private institute GfK, which register the consumption of app. 2300 households of organic and conventional foods and the corresponding prices. 20% of the households are exchanged every year, partly because of households leaving the survey, and partly in order to ensure that the panel is representative for the Danish population. The panel is representative with respect to the location and size of the household, as well as age, education and job of the consumer. The consumers respond by recording their weekly consumption in a diary. This record encompasses 140 commodity groups, which represents 80% of the consumer's budget for grocery shopping. Data for organic foods exists for the period from the beginning of 1997 to the end of 1998.

4. Model

The theoretical foundation for the model used in our study is utility maximising behaviour in a perfect market. The model is formulated such that the consumers demand foods in a manner that they minimise their expenditure subject to their preferences. The optimal budget share is a function of relative prices, income or budget of the consumer and possibly other explanatory variables. The model applied in our study is the Almost Ideal Demand System (AIDS), which was introduced by Deaton and Muellbauer (1980), cf. Appendix A.

For dairy products, we specify a demand system consisting of two equations – one specifying the optimal budget share for the organic commodity and one for the conventional commodity, using the total (conventional plus organic) consumption of this commodity as the budget. Using the homogeneity assumption (implying that a proportional rise in all prices and expenditure has no effect on demand, cf. appendix A) together with the adding-up assumption (implying that the budget shares add up to unity, cf. appendix A), these equations may be reduced to one:

$$s_{o,i}^{t} = \alpha_{o,i} + \gamma_{o,c,i} \log\left(\frac{p_{c,i}^{t}}{p_{o,i}^{t}}\right) + \beta_{o,i} \log\left(\frac{y^{t}}{P^{t}}\right) \qquad (1)$$

where $s_{o,i}$ is the optimal budget share of organic product i in the t^{th} period,, α_o, β_o, *and* $\gamma_{o,c}$ are parameters, $p^t_{c,i}$ is the price of the conventional produced product i in the t^{th} period, $p^t_{o,i}$ is the price of the organically produced product i in the t^{th} period, y^t represents total total expenditure in the t^{th} period (approximating life time income), and P^t is the Laspeyre's price index in the t^{th} period (Phlips, 1983). The rest of the parameters can be calculated from the restrictions and the conventional budget share can be found residually.

Various model specifications were estimated and tested from using the Likelihood Ratio test (cf. Harvey, 1990). The following characteristics were tested for: (1) Homothecity, (2) Dynamics and (3) Linear and quadratic trends, where the numbering shows the test order.

The trends are assumed to describe several situations in which the consumption increases even though the prices do not change. First, marketing of organic foods in the media as well as exposition in the shops has intensified during the period. These factors have drawn attention to organic foods. Second, negative media coverage and critical articles about conventional production and food safety have probably had a positive effect on demand too. Finally, the supply of some types of organic foods has increased during the period. In reality, some organic food types have been sold out in periods and excess demand has occurred.

The model (1) were embedded with dynamics given by the Error Correction Model, which specifies the dynamic path to the long-run equilibrium (cf. Appendix A). The gradual adjustment may be interpreted in several ways, e.g. as due to habits in private consumption or imperfect information implying that consumers are not aware of price changes immediately.

Finally, homothecity were tested for. Homothecity implies that the optimal budget shares are independent of total expenditure y^t. In model (1), homothecity is ensured by adding the restriction $\beta_{o,i} = 0$. In a homothetic model, the budget elasticity equals unity.

For the estimation, TSP version 4.4 was used. In the linear single equation model of this study, the estimator is ordinary least squares. For more information, see Hall and Cummins (1997). The dynamic model is estimated in one step. Alternatively, the so-called 2-step or Engle-Granger Method (Engle and Granger, 1987) could be used whereby the long-run relationship is determined first, followed by estimation of the short-run dynamics. This method, however, may yield poor results with small samples, as the estimates in the long-run relationships can be biased (Stock, 1987; Banerjee et al., 1986). Since the sample in the present study is relatively small, only the 1-step procedure has been applied. For identical reasons, the Johansen method (Johansen, 1988, Johansen and Juselius, 1990), which combines cointegration and estimation, is not used.

5. Results

In general, it is not a problem to ensure the negativity condition, as all compensated own price elasticities are negative. Dummy variables are used in order to describe the effect of campaign weeks that took place in 1997 in outlets of the largest seller of organic foods in the Danish market, the supermarket chain FDB.

The elasticities presented in this work are *Marshallian price elasticities* (i.e. uncompensated price elasticities), because these are most often reported in the literature, and are therefore used for the sake of compatibility[1].

Our model specifications were tested using the Likelihood Ratio test. For the results of these tests, see Wier and Smed (2000). Table 2 reports the estimation results for the preferred model specification, which is a homothetic, static model with a linear trend. Table 2 shows own and cross price elasticities, which are the percentage changes in the consumption of the commodity *i* as a consequence of a 1 per cent increase in the price of the commodity *j*. The trend in the budget share (*ds/dt*) are expressed as the change in budget share per four

Table 2. Estimation results for the preferred model specification

	Price elasticities		**L**	**R^2**	**t-stat for** [illegible]$_{ij}$	**DW**	**LM**
	Organic	Convent.					
Organic	-2.27	1.27	113.71	0.94	2.27	1.73	0.84
Convent.	0.13	-1.13					

weeks, *L* is the logarithm of the Likelihood function for the whole model, R^2 is the coefficient of determination. Finally, the table shows the *t*-value for the price

[1] In principle, Hicksian elasticities are the most unambiguous, as they measure price effects only, compensated for income effects. However, the Hicksian elasticity assumes that the consumers are compensated for the change in income and that does not reflect reality – consumers do not get compensated in income every time prices change. Rather they change their commodity mix at a given income and the Marshallian elasticity measures that change.

parameter (the critical value $t_{0,025}$ = 2.056), Durbin-Watson (DW)-statistics for the presence of 1st order auto-correlation, and the Lagrange Multiplier (LM) test for heteroscedasticity (Harvey, 1990).

The model is characterised by high own price elasticities. In comparison, the absolute of price elasticities for foods are generally smaller than 2 (Wier and Smed, 2000). The high price elasticities can be explained by the fact that conventional and organic commodities are very close substitutes. The consumption of conventional products shows only a low sensibility to changes in prices of organic foods. This is due to the large budget share of conventional foods.

The R^2 value is high. The t-statistics are high enough to ensure significant parameter estimates, and the DW-statistics are so close to 2, that the hypothesis of no 1st order auto-correlation cannot be rejected. The LM-statistics are so small that the hypothesis of no heteroscedasticity cannot be rejected at the 5% level. Appendix B show actual and fitted budget shares (left graph), as well as residual plots (right graph) for each commodity group.

In order to test for a cointegrating long-run relationship, two alternative tests are performed. One is the Dickey-Fuller test, which first tests whether the relative prices and the budget shares are integrated in the first order, and then whether the long-run relationship cointegrates. The other test is the ECM test, which uses the t-statistics for the k_2 parameter in (2) (cf. Appendix A), which characterises the long run dynamic path to the optimal budget share (Kremers *et al*., 1992). This method examines, whether the k_2 parameter in the dynamic model equals zero by using its *t-stat* and testing it against the critical value given by Banerjee, Dolado and Mestre (1993). If it cannot be rejected that k_2 equals zero, then there is no cointegration. In other words: if it can be rejected that k_2 equals zero, then the variables are tied so strongly together in the long run that it can be rejected that there is no cointegration.

The ECM test is based on a model including the dynamics. In contrary, the Dickey-Fuller test is solely based on the long-run relationship, making it a little weaker than the ECM test, while the ECM test benefits from the information on the short run. (Kremer *et al*. 1992).

Table 3. Testing for cointegration

Dickey-Fuller Tests	*Testing for the order of integration for relative prices and budget shares* *Null hypothesis: No integration of zero order*		
	DF test stat.	Conclusion at 5% level*	Integration order
- Budget shares	-2.32	Not rejected	First order
- Relative prices	-2.17	Not rejected	First order
	Testing for cointegrating long-run relationship *Null hypothesis: No integration of zero order*		
	-4.47	Rejected	Integrated of zero order, i.e. cointegration
ECM Test	*Testing for cointegrating long-run relationship,* *Null hypothesis: $k_2 = 0$, i.e. no cointegration. Critical value 4.18***		
	t-stat	Conclusion at 5% level*	Integration
	4.15	Not rejected	No cointegration

* We apply MacKinnons critical values from the TSP-package, which is slightly different from the values in Fuller (1976). MacKinnons are calculated with a finer grid. The DF tests are augmented, including lagged values in order to assure uncorrelated residuals. Furthermore, trends and constant terms are included in the models, if significant. See the TSP-manual Hall and Cummins (1997) for more information.
** Critical values from Banerjee, Dolado and Mestre (1993).

In the upper part of Table 3, the result of the DF-test is that it cannot be rejected that the relative prices and budget shares are not integrated of zero order (thus, they are integrated of first order). The result of the DF test for cointegrating long-run relationship is that the long-run relationship is integrated of zero order, thus indicating cointegration. In the lower part of Table 3, the result of the ECM-test is reported, and here the null hypothesis of k_2 being equal to zero cannot be rejected, as the t-stat is too small to allow this conclusion. This result is contradicting the result of the DF-tests. However, as the t-stat is very close to its critical value we may presume cointegration, considering the small sample (25 observations).

6. Further research

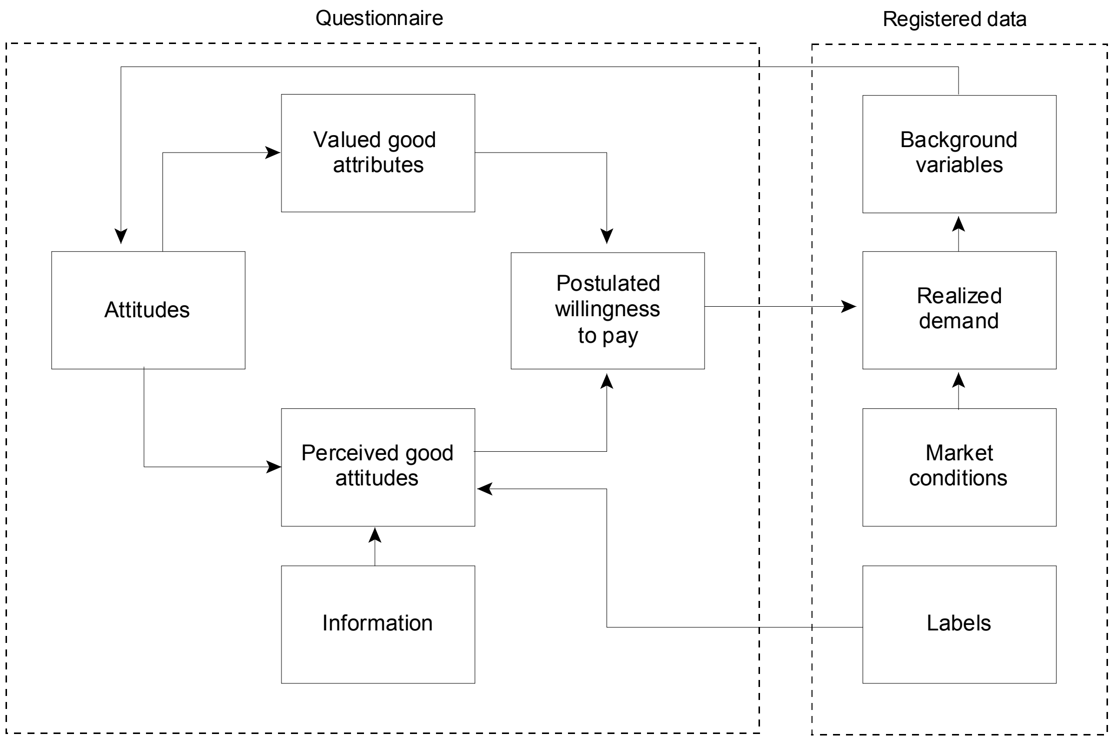
During 2001-2005, we are continuing our research on demand for organic foods. In our current project, the individual households' consumption of organic foods is modelled, and its dependence on important factors such as prices, household income, geographic location, consumers' occupation, age, number of children, etc. This is done both for individual goods and aggregated commodity groups of Danish as well as foreign consumers, including estimates of demand curves plus price and income elasticities. Identifying differences in demand parameters for different types of households is both important as part of understanding the willingness to pay (for organic foods as compared to conventional foods) of different consumer segments and as part of an evaluation of the market potential.

The results presented in this paper are based partly on the same data applied in our current study. However, in the former project, the analysis was based on aggregated data (i.e., total Danish consumption of aggregated commodity groups). In the continuing project, in contrary, the analysis applies information at the individual household level (panel data), which makes possible a much more detailed and informative approach. Furthermore, as GfK has household panel data from several other European countries, we will apply data from other countries as well. Finally, the modelling is supported by a questionnaire, surveying households in the very same panel as applied in the model estimations. An essential feature and ultimate strength of the project is that it can reveal differences between actual and postulated behaviour and enlarge the analyses by information on attitudes, values, food habits/eating patterns and food interests.

The detailed demand modelling at household level makes it possible to estimate aggregate demand as a function of economic variables like prices and income, and as a function of the share of different types of households. This makes possible the evaluation of the effect of policy instruments such as subsidies, labelling, information etc. on total consumption as well as on individual consumer segments. Furthermore, it will be possible to examine changes in aggregated demand function (and thus the effect of different policy instruments) as a result of expected demographic developments under different assumptions of developments in sales channels and food culture (attitudes towards imported goods, preferences in relation to prepared/unprepared products etc.).

The core of the project is to establish the parameters of a utility based model of household preferences for organic food incorporating explicit representation of valued product attributes and relevant underlying attitudes. Data for parameterisation can be divided into nine types and will be collected through two vehicles, according to Figure 1.

Figure 1



On the basis of focus group interviews we will structure the theoretical model of household preferences and the questionnaire. Panel data estimates will then be used to estimate the system of demand equations derived from the model of household preferences. Subsequently, the estimated system will be used for evaluation and simulation.

The use of household level panel data has at least three advantages over estimations based on aggregated data. First, it becomes possible to take account of variation in unobserved time-invariant household background variables by modelling with fixed/random effects and coefficients. It is well known that not taking account of such effects may result in substantial parameter bias. Second, household level data make it possible to systematically explore and test the effects of observed background variables. These are to some extent implicitly assumed a priori when data are aggregated. Finally, the substantially higher number of observations makes it possible to estimate more sophisticated models than when data are aggregated to fewer observations.

The proposed survey of a sample of consumers will be designed to identify those motivations ranked highest among consumers in determining their choice of organic produce: e.g. personal health risks, domestic animal welfare or concern for the environmental quality? Considering that organic produce presents a bundle of different characteristics to the consumer (health benefits, environmental benefits, taste, appearance), the method of choice experiments is probably most suited to evaluate consumer preferences for different attributes.

Based on the modelling results, a large number of analyses may be carried out. The main analyses are listed below:

- If the price sensitivity of organic food consumption is high, it means that the price conditions between the two groups are decisive determinants for the demand for organic products. This also means that policy instruments like levies and subsidies will be effective. Scenarios of the effect of the instruments will be carried out.
- Examination of differences between postulated willingness and observed willingness to pay and analysis of the implications of that in relation to food demand studies.
- Examination of differences in people's confidence in organic product labelling among countries and among different consumer groups within the individual countries and evaluation of labelling as a regulatory instrument.

- Analysis of differences in food consumption and consumer preferences from country to country, based on the identification of the explanatory factors behind the differences. Of particular interest are differences in food culture (favourite types of food, attitudes towards imported goods, preferences of prepared/unprepared products, etc.), and differences in sales channels (whether the products are sold in supermarkets, through alternative sales channels like health-food shops, in farm shops, food co-ops, or on markets).
- The development in market potential for organic food at home and abroad as a result of the demographic development under differently assumed changes in sales channels, processing technology, product development, policy instruments, food culture, etc. will be examined through scenario calculations.

7. Conclusions

The market of organic dairy products has experienced tremendous growth during the period 1997-1998, as the volumes share of dairy goods has increased by 55%. As our modelling shows, most of this development can be explained by decreasing relative organic prices. Estimation of price elasticities reveals that price sensitivity in demand for organic dairy products is high, compared to other food demand studies. An important reason for the high elasticities is that the organic and conventional dairy products are close substitutes. Thus, our study indicates that measures such as subsidies to organic products or production, levies on conventional agricultural products, or levies on pesticides or commercial fertilisers will have remarkable effects on the consumption of organic foods.

In our ongoing study, we will examine how organic demand is related to consumer attitudes and values, as well as socio-economic and demographic characteristics and how these variables act together with market conditions such as prices, marketing and sales channels. Finally, we will analyse the effects of policy instruments such as labelling of organic products, subsidies, levies, consumer information, and promotion of the products.

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Appendix A

In the AIDS system, the optimal budget share s_i for commodity i in the t^{th} period is specified as:

$$s_i^{\,t} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_j^{\,t} + \beta_i \log\left(\frac{y^t}{P^t}\right)$$

where α_i, β_i and γ_{ij} are parameters, p_j is the price of commodity j in the t^{th} period, y is the nominal disposable income or budget of the consumer in the t^{th} period, and P is a price index in the t^{th} period. Most often, a linear price index is used, and the model is then called Linear Almost Ideal Demand System - (L)AIDS. Furthermore, the following restrictions are obtained: (1) price-homogeneity (i.e. the demand function is homogeneous of degree zero in total expenditure and prices), (2) adding up (which follows from the budget constraint and the monotonicity assumption of preferences) and (3) symmetry (i.e. the substitution matrix is symmetric):

$$\sum_{i=1}^{n} \alpha_i = 1,\ \sum_{i=1}^{n} \gamma_{ij} = \sum_{j=1}^{n} \gamma_{ji} = 0,\ \sum_{i=1}^{n} \beta_i = 0, \text{ and } \gamma_{ij} = \gamma_{ji}$$

In order to take account of habit forming, adjustment cost etc., the dynamic behaviour of our model is given by the Error Correction Model which specifies the change in budget shares from time *t-1* to time *t* as

$$s_{i,t} - s_{i,t-1} = k_1(s^*_{i,t} - s^*_{i,t-1}) + k_2(s^*_{i,t-1} - s_{i,t-1}), \qquad (2)$$

where k_1 and k_2 are parameters characterising the dynamic path to the optimal budget shares s*, given in Equation (1)

Appendix B

Figure B.1 Observed and fitted budget shares for organic dairy products