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Demand Structure and Willingness to Pay for Organic Dairy Products

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Abstract. This paper analyses if the introduction of a new and "low fat" organic variety of fluid milk has any effect on consumers' valuation of organic milk in general and can rewind the stagnating trend in the demand for organic milk. In order to analyse this, the consumers' purchasing structure was analysed and it was found that consumers first chose between different types of milk and secondly, decided of whether this milk was organic or conventional. Elasticities indicated a greater temporary flexibility in the demand structure and a permanent change of substitution patterns through the introduction of the new type of milk. The calculation of marginal Willingness to Pay show a temporary raise in consumers' valuation of the organic quality attribute, but this was followed by a decline.

Keywords: Organic milk, AIDS model, WTP, separability

1. Introduction

The interest for organic food products has been growing rapidly during the 90's in many Western countries. This growth has been especially high in Denmark where organically produced foods make up 5% of the total food budget. For some products such as milk, eggs and carrots the shares are above 20% [1]. However in recent years it seems as if this growth has met its limits and for some food products the positive trend seems to have stagnated or even become negative. It is thus important to obtain detailed knowledge of the consumer's interest and demand for organic foods in order to be able to predict the market potential of organic foods and to know if the downward trend in demand can be reversed. Recent studies are mainly founded on stated behaviour and only few studies of demand for organic foods are based on actual purchasing data. Exceptions are Glaser and Thompson [2], Jörgensen [4], Wier and Smed [5] and Millock *et al.* [6]. The Danish markets for organic foods, especially for products like eggs, milk and some vegetables are well suited for demand analysis since these markets do not suffer from supply shortages and barriers which dominate in organic markets in many other countries. The reasons are that, many of the most common organic products are sold in supermarkets where consumers already do their shopping. The price premiums for these products are relatively low and consumers have trust in the certification and labelling system [7, 8].

In February 2001, a new "low fat" milk variety was introduced in the Danish milk market. In the first 9 months only the organic version was introduced. Among the questions posed in this paper is whether this market introduction strategy in general has increased consumers' interest in organic milk, and furthermore, if this implies that introducing new and "trendy" organic products can reverse the downward trend in demand for organic products.

Three procedures are followed in this paper in order to analyse the market for organic milk – 1) the choice structure is analysed - 2) ordinary price and budget elasticities estimated and finally, -3) calculation of average marginal Willingness to Pay. This structure is chosen since the

decision structure is of major importance. When the consumer goes shopping, does she firstly choose which fat content or taste of milk to consume and thereafter in the second step decides whether this milk has to be either organic or conventional? Or does she first decide if her milk has to be organic or conventional and then in the second step decide which type of milk to consume? Price and budget elasticities shows the structures of substitutions among different milk types and finally estimated Willingness to Pay shows the value consumers place on the organic quality attribute. That consumers are willing to pay more for a litre of milk, only distinguished from the conventional types by the organic attribute, indicates that the consumer associates organic milk with some quality attribute not offered by the conventional variety.

2. The Danish market for organic milk

The first litre of organic milk was produced in 1988 and organically produced milk has had an increasing share of total consumption until the middle of 1998 and it seems like the organic share has stabilized around 25% since then (see Figure 1).

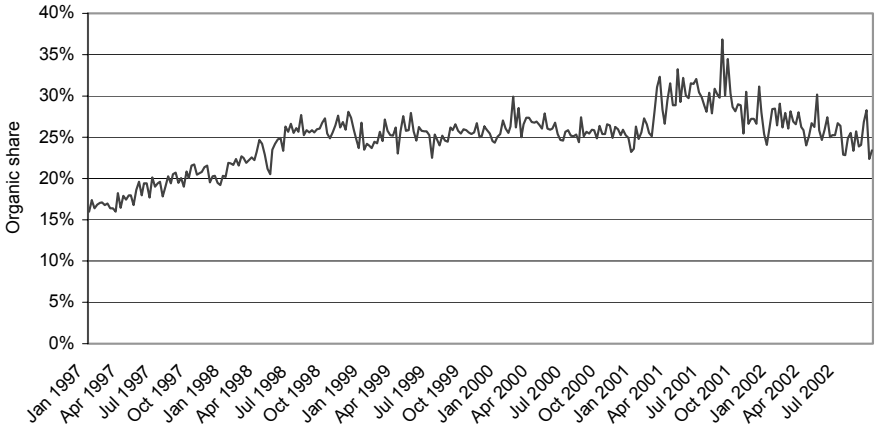

Figure 1. Average organic share for fluid milk, Jan 1997 to Sept 2002
Source: Own calculations from Gfk data

The Danish milk market consisted, until February 2001, of 4 major types of fluid milk: Whole -, "light"-, skimmed- and buttermilk, all with substantial differences in taste and fat content[1] and all provided in both an organic and a conventional variety. In February 2001 a new type of fluid milk was introduced in the market with a low fat content like that of skimmed milk and a taste almost like "light" milk. Within the first 9 months this kind of milk only existed in an organic version, which is the reason for the large increase in the total organic share in Feb/Apr 2001 as is seen in figure 1. In September 2001 the conventional version arrived and a decline in the average organic share is seen in figure 1. Price premiums for organic milk lay around 20%, which are lower than in Glaser and Thomson [2] who find a premium at 60 –75 % on the organic market in the US[2].

The organic share of milk is not evenly distributed across the different types of milk as is seen from Figure 2.

[1] Whole milk has a fat content of 3.5%, "light" milk 1.5% and skimmed milk max 0.5% (Most skimmed milk has a fat content of 0.1%, but the actual fat content is dependent on the race of the cow).

[2] The low price premium at the Danish market may be due to the fact that most organic milk in Denmark is sold in ordinary supermarkets.

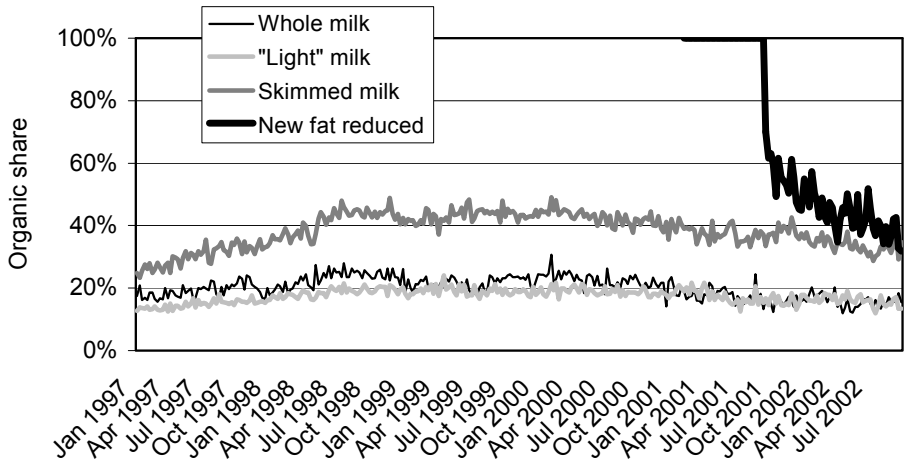

Figure 2. Organic share for various kinds of fluid milk Jan 1997 to Sept 2002
Source: Own calculations from Gfk data

In 1999 almost half of the sold skimmed milk is organic while the organic share of the other types of milk varies around 20%. The organic share of the new type of fat reduced milk has been steadily declining after the introduction of the conventional type and tends to fall towards the 20 - 30 % level like the other types of milk.

3. Empirical implementation and data

3.1 Demand specification

We assume weak separability between the demand for fluid milk and the demand for other commodities. The demand functions for milk are formulated according to the Almost Ideal Demand (AID) specification, introduced by Deaton & Muellbauer [12], where commodity *i*'s share of the total commodity group budget can be derived:

$$w_{it} = \frac{p_{it} q_{it}}{y_t} = \alpha_i + \sum_j \gamma_{ij} \ln p_{jt} + \beta_{iy} (\ln y_t - \ln P_t) + \beta_{it} \cdot t_t + \varepsilon_{it} \quad (1)$$

where p_{jt} is the price of commodity (milk type) *j* at time *t*, y_t is the size of the total budget for fluid milk consumption, ε_{it} is the error term $\varepsilon_{it} \sim N(0,\sigma^2)$, t is a linear trend variable and $\ln P_t = \alpha_0 + \sum_k \alpha_k \ln p_{kt} + \tfrac{1}{2} \sum_k \sum_j \gamma_{kj} \ln p_{kt} \ln p_{jt}$ is an aggregate price index. The latter can be approximated using the Törnquist index [13], $\ln P_t - \ln P_0 = \sum_k \tfrac{1}{2}(w_{k0} + w_{kt}) \cdot (\ln p_{kt} - \ln p_{k0})$ The system of budget share equations is required to satisfy the properties of adding-up, linear homogeneity and Slutsky symmetry, which can be introduced by restrictions on the parameters.

From the estimated coefficient estimates, we can calculate budget and own- and cross- price elasticities respectively [14] according to the formulae:

$$E_i = 1 + \frac{\beta_{iy}}{w_i} \quad (2)$$

$$e_{ij} = \frac{\gamma_{ij} + \beta_i \left[\beta_j \ln\left(y / P \right) - w_j - \frac{1}{2} \sum_k \left(\gamma_{kj} + \gamma_{jk} \right) \ln p_k \right]}{w_i} - \delta_{ij} \quad (3)$$

The unconditional elasticities are calculated from the conditional elasticities [15] according to the following formulae:

$$E_i = E_{(R)i} \cdot E_{(R)} \tag{4}$$

$$e_{ij} = \delta_{RS} e_{(R)ij} + E_{(R)i} w_{(S)j} \left[\delta_{RS} + e_{(R)(S)}\right] \tag{5}$$

Where δ_{RS} is Kronecker delta equal to 1 for $R = S$ and 0 elsewhere. $E_{(R)i}$ is the budget elasticity for good i in group R, $E_{(R)}$ the total group budget elasticity and so forth. As data for the long-term development of the demand for different types of milk in Figure 2 show, there are trends in the consumption of organic fluid milk. Under the assumption that preferences have changed smoothly over the observation time a trend variable can provide a useful proxy for these effects [15, 9]. Dummy variables are included for specific weeks representing seasonal patterns.

3.2 Implementation of WTP in the AIDS system

The consumers' valuation of different products relative to each other (WTP) is roughly given by the set of marginal rates of substitution. As the marginal utility $\partial U / \partial q_i$ for a product (with specific quality attributes) is a decreasing function of the quantity consumed, calculation of marginal willingness to pay for different quality attributes (e.g. taste and health) requires the same level of consumption for all considered varieties. This can be obtained by inverting the system of demand equations, assuming identical consumed quantities of the considered quality varieties and solving for the implicit price vector θ. The marginal rate of substitution for any pair of varieties i and j, derived at the level of consumption $\bar{q}$ for each of the varieties is then given by the ratio:

$$\left.\frac{\partial U / \partial q_i}{\partial U / \partial q_j}\right|_{q_i, q_j = \bar{q}} = \frac{\theta_i}{\theta_j} \tag{6}$$

In the present context, we consider the relative WTP's for conventional and organic varieties of milk for different types of milk. This means keeping all quality attributes, but the organic attribute equal. In the AID specification, equal quantities are translated into equal budget shares, assuming that prices are exogenous (at the observed level).

$$\overline{w_i} = \frac{p_i \bar{q}}{\sum_{j=1}^{k} p_j \cdot \bar{q}} \quad , i = 1, \ldots, k \tag{7}$$

where $\sum_{i=1}^{k} \overline{w_i} = \sum_{i=1}^{k} w_i$ and k=2. Setting the demand equations in (1) equal to these hypothetical budget shares and solving these equations for the implicit prices of the considered products, θ_i, $1, \ldots, k$, leads to the relative willingness to pay: θ_i / θ_j between any pair of considered products. (Due to linear homogeneity, the absolute willingness to pay cannot be determined).

3.3 Utility structure

In order to identify if it is possible to maintain consumers interested in organically produced milk, it is of main importance to understand the separability structure of the consumers. Two separability structures are assumed and tested as shown in Figures 3 and 4. In the first structure (Figure 3), consumers dedicate a certain share of their budget for fluid milk to organic milk.

Subsequently, the consumers choose between the different types of milk (whole-, light- etc.). This structure implies that the introduction of a new type of milk in only an organic version will mainly compete with the other types of organic milk and can only influence the consumption of the conventional types through the budget.

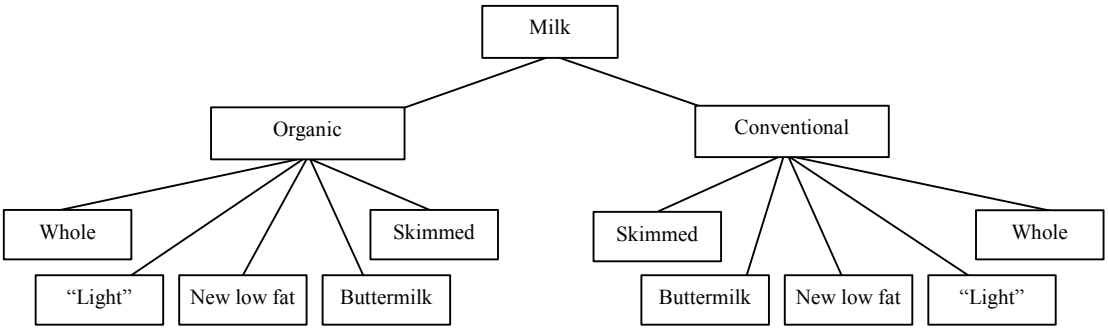

Figure 3. Separability structure 1

In the second structure (Figure 4) consumers choose between different types of milk in the first step and whether milk has to be organic or conventional in the second step. This second structure allows for a larger increase in the average organic share of fluid milk by introducing new types of milk in only an organic version, as substitution towards this new type of milk means substitution in favour of organic milk. Finally, the last possibility is that there is no structure at all so the different types of milk are chosen simultaneously.

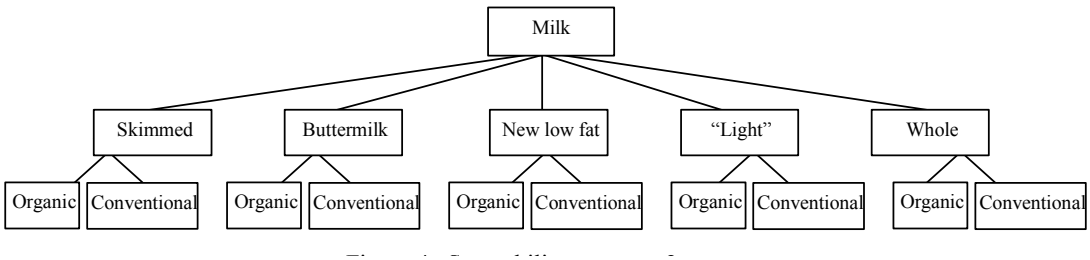

Figure 4. Separability structure 2

These separability structures lead to a number of restrictions, which are imposed on the equations in the AIDS system[3] and tested. In order of comparison the second structure is the line followed in Thompson and Glaser [3]. The detailed estimation procedure is presented in appendix 1.

3.4 Data

The data material for the empirical analysis consists of a time series aggregated from a representative household panel of Danish food consumers (approximately 2000 households) from Gfk Denmark, spanning the period from January 1997 to September 2002. Weekly shopping reports are collected from the households, reporting the households' purchases in terms of quantity, value, price, brand, special product characteristics (e.g. organic), shop, etc. In principle, the data material might enable use of micro-econometric methods for analysing the demand for milk, if the panel structure of the data has to be exploited fully. However, in this respect, the data material has one shortcoming: it only contains price information of the

[3] The exact implementation of the restrictions are shown in Appendix 1

commodities purchased, whereas information concerning the prices of commodities not chosen by the individual consumer is either non-existing or imperfect. This limitation may be serious in the present context, as the theoretical model specifies demand of a specific milk type as a function of the prices of selected as well as rejected types of milk. For this reason, the data have been aggregated to pure time series data

4. Results

Basically, three models are estimated – representing three sub-periods:

- One before the introduction of the new milk type (period Jan 1997 – Feb 2001)
- One in the intermediate period where only an organic version of the new low fat variety is introduced (period Feb 2001 – Sep 2001)
- One where also a conventional version of the new fat reduced is available (period Sep 2001 – Sep 2002)

All three models are estimated using the Seemingly Unrelated Regression method (SUR) and the assumptions of adding up, homogeneity and symmetry were imposed and tested one by one and were all accepted at a 5 % significance level. Significance of the remaining parameters was tested and a reduced model was tested against the unreduced model and accepted at a 5% significance level. Godfrey's test shows no signs of autocorrelation. Breusch–Pagan tests show no heteroscedasticity in any of the equations in the model either before or after the introduction of the new type of milk[4].

Table 1. Results from the tests of separability for period 1 and 3

		LR	Pr > chi sq	Wald	Pr > chi sq
Period 1	Structure 1 versus no structure	45.59	<0.0001	62.62	< 0.0001
	Structure 2 versus no structure	5.10	0.9544	7.55	0.8194
Period 3	Structure 1 versus no structure	33.58	0.0206	26.85	0.1083
	Structure 2 versus no structure	26.64	0.2254	25.53	0.2725

Table 1 depicts the results derived from tests of separability where each of the separability structures shown in Figure 3 and Figure 4 are tested against the hypothesis of no structure in milk demand. In the first period, there is a clear rejection of the first separability structure, whereas the second structure cannot be rejected. This picture is the same in the third period but is less clear indicating that the introduction of the new fat reduced type of milk to some extent has broken up the structure of milk demand. In general this implicates, that the consumers' choice of milk first depends on taste and fat content and subsequently on mode of production[5].

[4] Due to space limitations, the direct estimation results are not reproduced here but can be obtained from the author upon request.

[5] As the test is based on an average value different sub periods are also chosen as a trial of the validity of the test. This does not change the main conclusions.

This also implies that an introduction of the new type of milk in only an organic version leaves room for an increase in the average organic share of fluid milk, which is also the picture seen in Figure 1.

Unconditional[6] price and budget elasticities are calculated for period 1 and 3 and are indicated in Table 2 and Table 3. These are estimated to be rather high (normally, food price elasticities are less than 2 and often less than 1). The high elasticities estimated in this paper are probably due to the fact that observations are on weekly basis, but also the fact that they represent demand for rather close substitutes due to nesting structure and separability assumptions. Similarly high elasticities for close substitutes estimated on weekly data are found in Jörgensen [4], Wier and Smed [5] and Thompson and Glaser [3].

Table 2. Unconditional elasticities for period 1

			Whole milk		"Light" milk		Skimmed	
			Org	Conv	Org	Conv	Org	Conv
Price of		Budget	0.88	1.03	1.15	1.05	1.05	0.97
	Whole milk	Organic	-1.37	-0.01	0.03	0.02	0.00	0.00
		Conventional	-0.14	-1.41	0.10	0.09	0.00	0.00
	"Light" milk	Organic	0.05	0.05	-2.25	0.20	0.07	0.06
		Conventional	0.22	0.25	1.02	-1.38	0.31	0.28
	Skimmed	Organic	0.00	0.00	0.07	0.07	-1.54	0.32
		Conventional	0.00	0.00	0.107	0.10	0.59	-1.36

For skimmed and "light" milk own price elasticities are larger for the organic version than for the conventional version. This is in line with results from Wier and Smed [5] who found own price elasticities for organic dairy products to be –2.27 and for conventional at –1.13. Thompson and Glaser [3] found own price elasticities for conventional milk (in the period 1990 to 1996) to be between -1.89 and -1.13 and between -2.06 and -3.23 for the organic version. Cross price elasticities are in general high, indicating that the organic and conventional versions of the same type of milk are close substitutes. The effect from a price change of the conventional version on consumption of the organic version is larger, in elasticity terms, than the opposite, which reflects that the organic shares are considerably lower than the conventional. This pattern is less evident for skimmed milk, which has the largest organic share among the milk types. The low substitution between conventional and organic whole milk indicates that it is different consumers buying the two types of milk. Consumers buying whole milk are mostly 60 years of age or more, while the largest shares of organic whole milk is held by those of 26 years of age or less [17]. In period 3 price elasticities for the organic version of "light" and skimmed milk has risen compared to period 1. This indicates that the "low fat" variety of milk is a substitute for both types of milk, but especially for "light" milk. Cross price elasticities show that a price change of both the organic and the conventional "low" fat milk affects consumption of both varieties of "light" milk. Also cross prices elasticities have risen between the conventional and the organic types of "light" milk and skimmed milk, respectively.

[6] These elasticities are unconditional in the sense that they are of course still conditional if we consider all kinds of food in a larger system

Table 3. Unconditional elasticities for period 3

			Whole milk		"Light" milk		Skimmed		"Low fat" milk	
			Org	Conv	Org	Conv	Org	Conv	Org	Conv
		Budget	0.61	0.55	1.00	1.00	1.21	0.99	1.13	1.00
Price of	Whole milk	Organic	**-1.08**	-0.07	0.05	0.10	0.06	0.01	0.01	0.01
		Conventional	-0.31	**-1.38**	0.26	0.30	0.06	0.05	0.05	0.04
	"Light" milk	Organic	0.13	0.12	**-3.63**	0.30	0.00	0.00	0.13	0.11
		Conventional	0.71	0.64	1.38	**-2**	0.02	0.02	0.65	0.58
	Skimmed	Organic	0.00	0.00	0.00	0.00	**-1.76**	0.33	0.00	0.00
		Conventional	0.00	0.00	0.00	0.00	0.9	**-1.4**	0.00	0.00
	"Low fat" milk	Organic	-0.01	0.00	0.14	0.10	0.00	0.00	**-2.51**	-0.40
		Conventional	-0.01	-0.01	0.16	0.20	0.00	0.00	-0.15	**-2.51**

Marginal willingness to pay for the organic versions of milk are calculated for period 1,2 and 3 according to (6) and (7) in order to identify if the introduction of the new "low fat" type of milk in initially only an organic version has changed consumers' valuation of the 'organic' attribute[7]. The results are presented in table 4. In the first period consumers were willing to pay, between 7 to 12 % extra for a litre of organic milk in the second period, when the new organic low fat milk is introduced, the valuation of the organic attribute rose to between 11 to 21 %. Finally, when the conventional version of the new low fat milk was introduced on the market, consumers are willing to pay between 7 and 21 % extra for the organic attribute. Millock *et al.* [6] found actual willingness to pay for the organic attribute to be 24% for the period June 1999 to May 2000, but the methods of calculation were not equivalent to those being used in the present paper.

Table 4. WTP for the organic attribute calculated for period 1 (January 2000 – January 2000), period 2 (March 2001- Sept 2001) and period 3 Sept 2001 – Sept 2002)

	Jan 2000 - Jan 2001	Mar 2001 – Sept 2001	Sept 2001 – Sept 2002
Whole milk	1.12	1.11	1.21
"Light" milk	1.09	1.14	1.07
Skimmed milk	1.07	1.21	1.08
Low fat reduced			1.07
Average value[8]	1.09	1.17	1.09

For both "light" and skimmed milk marginal willingness to pay seems to be larger in the second period where only the organic version of the new type of milk is on the market. This indicates a larger valuation of the organic attribute in that period. For skimmed milk this is also reflected in a rising organic share. For both varieties WTP declines as the conventional version of the new type of milk is introduced. On long term basis the marginal willingness to pay for the organic attribute is unchanged by the introduction of the new "low fat" type of milk.

[7] In order to make values comparable, period 1 is reduced to cover only the year 2000

[8] This average value is calculated as the marginal Willingness to pay times the relative market shares of the different types of organic milk.

5. Discussion

The estimated structure of Danish consumers' milk demand shows that, first consumers choose between which type of milk to purchase and then in a second step, decide if this milk has to be organic or conventional. Therefore, the increase in the organic share of one type of milk mainly competes with the conventional share of the same specific kind of milk rather than the other types of organic milk. This structure indicates that it might be possible to increase the average organic share of organic milk by increasing the share of just one type. Further research could consider the purchasing structure for other types of organic foods or consider the separability structure between organic and conventional foods for larger demand systems. In general, it would also be beneficial to consider if this separability structure is valid for all types of consumers or some groups have another structure of demand. This is especially important if the aim is to increase the average organic share for specific groups of consumers.

Generally, the introduction of a new type of milk has introduced more flexibility in milk demand as price elasticities have increased, at least for a short period of time. Generally it seems like the initial structures of substitution between certain types of milk have changed. Conditional cross price elasticities are generally high, indicating that the organic and conventional versions of the same type of milk in general are close substitutes. Another way of increasing the average organic share may be through changing relative prices in favour of lowering the price of organic products since both own- and cross-price elasticities are rather high.

The average Willingness to pay for the organic attribute is positively affected by the introduction of the new type of milk in only an organic version. But from the results in this paper it seems like this stimulating effect is only of a temporary character. When the conventional variety is introduced, valuation of the organic attribute is back to its original level. This implies that valuation of the organic attribute cannot be increased on a more permanent basis by the introduction of new and trendy product in only an organic version. Calculations of marginal WTP for various socio-economic groups would give useful insights in milk demand. The limited effect on general demand for organic milk from the introduction of this new type of milk might be dependent on the type of consumer. There might be considerable effects on some groups and limited effects on others depending on which products are introduced.

The results might also be limited in terms of only covering aspects of milk demand. For the purpose of deriving more broad conclusions demand for more organic products should be analysed. Another limitation of our analysis is the fact, that both the organic and the conventional variety of the new "fat reduced" types of milk are new on the market. An analysis along a larger scope of demand for the new type of organic and conventional variety could give further insights as well.

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Appendix: Calculation of test for separability

In demand analysis it is common to model the decision process of the consumers as a multistage or conditional process where e.g. the demand for milk only is a function of the prices of other dairy products and of total dairy expenditure. Such a procedure is justified if the consumer's direct utility function is weakly separable. Weak separability implies restrictions on the substitution possibilities for two goods belonging to different groups so that a price change of good *i* in one group only influences the consumption of goods in other groups through the budget. This means that substitution is proportional with the budget effect. According to results from Blackorby *et al.* [18] presented in Mochini *et al.* [11] the off diagonal elements in the Slutsky