AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

# What is it Consumers really want, and how can their preferences be influenced? The Case of fat in Milk*

Laura M. Andersen† and Sinne Smed‡

February 2012

**Abstract**

*In this paper we investigate preferences for fat in milk through a structural characteristics model. The data includes information about daily purchases and social and demographic characteristics of more than 1,100 households. We find that consumers who prefer milk with a high fat content do not react to information about health effects, but can be influenced by prices, while consumers who prefer milk with a low share of fat are influenced by information, but are less price sensitive. Therefore, when attempting to decrease consumption of fat from milk, prices are more efficient than information.*

Keywords: Fat in milk, Characteristics model, hedonic prices, information, panel data

JEL: D12

* The research was funded by the Danish Social Science Research Council (FSE).

† Contact information: Laura Mørch Andersen, Institute of Food and Resource Economics, FOI, www.foi.dk e-mail: LA@foi.ku.dk.

‡Sinne Smed, Institute of Food and Resource Economics, FOI, e-mail: SS@foi.ku.dk.

## 1 Introduction

Health problems related to the excessive intake of saturated fat are among the major nutrition problems in most industrialised countries, as a high intake of saturated fat can lead to increased blood cholesterol levels and a greater risk of various lifestyle-related illnesses. In Denmark, milk is a natural part of the diet and 10 percent of the total fat consumption and 16 percent of the total consumption of saturated fat comes from milk (Pedersen et al., 2010). The consumption of saturated fat from milk has decreased during the last decade (Statistics Denmark, 2008), which may in part be a reaction to massive campaigning on behalf of the Danish health authorities against the excessive intake of saturated fat, but is also, to a large extent, due to the entrance of low fat varieties on the milk market (Smed and Jensen, 2004). These changes on the milk market provide a good opportunity to investigate preferences for saturated fat, how they can be expressed through demand and how they change over time and how they change due to information.

In this paper, we investigate preferences for fat in milk through a structural characteristics model, i.e. a model in which consumers derive utility from the characteristics inherent in milk, not from milk itself (Lancaster, 1966; Gorman, 1980). We introduce systematic changes in preferences initiated by a trend and by exogenous health information. The data used for the estimations are based on an extensive panel dataset at the household level. This means that it is possible to estimate the models household by household, which facilitates the maximum degree of individual heterogeneity.

There is a need to understand the possible barriers to a further reduction in the intake of saturated fat since this knowledge may be essential for the design of new policy instruments aimed at reducing the intake of saturated fat. The derivation of a structural model for individual households brings us closer to separating preferences and changes in these due to, e.g. information from reactions to prices and budget constraints.

This separation gives us the opportunity to investigate whether prices or information would be the best policy instrument if the government wishes to reduce the consumption of fat from milk, and to shed light on which type of households would primarily be affected by such policies. This is the main purpose of this paper.

The rest of this paper is organised as follows: Section 2 discusses the basic theory of the characteristics model, which is followed by a description of the data and the milk markets in section 3. Section 4 discusses the construction of prices in the characteristics model and section 5 specifies the model using a quadratic utility function. Section 6 presents the results, i.e. valuation of fat and reactions to prices and information for different types of households. Section 7 is devoted to a discussion and conclusion.

## 2 The characteristics model

The characteristics model was first developed by Gorman (1980) and Lancaster (1966) and was further developed by Muellbauer (1974) and Rosen (1974). Generally, we assume that the world consists of $H$ individual households. The number of goods available in each period is $I$ and the number of characteristics is $J$. The connection between goods $q$ and characteristics $z$ is described through the technology matrix A.

$$
\begin{array}{c}
\\
\\
\\
\textit{Goods}
\end{array}
\quad
\begin{cases}
1 \\ \vdots \\ i \\ \vdots \\ I
\end{cases}
\overbrace{
\begin{array}{ccccc}
1 & \cdots & j & \cdots & J
\end{array}}^{\textit{Characteristics}}
\begin{bmatrix}
a_{11} & \cdots & a_{1j} & \cdots & a_{1J} \\
\vdots & \ddots & \vdots & \iddots & \vdots \\
a_{i1} & \cdots & a_{ij} & \cdots & a_{iJ} \\
\vdots & \iddots & \vdots & \ddots & \vdots \\
a_{I1} & \cdots & a_{Ij} & \cdots & a_{IJ}
\end{bmatrix} \equiv \mathrm{A} \tag{1}
$$

It is assumed that the amount of characteristics can be aggregated over goods (the utility of a characteristic does not depend on its origin) and the relationship is assumed to be linear, which means that the relationship between goods purchased and characteristics obtained can be written as:

$$z = \mathrm{A}'q \tag{2}$$

The technology matrix A is constant over households, which implies that all households meet the same A matrix, and we assume that it is constant over the time span used in our model (in principle the technology matrix A can change over time as products with new and previously unknown characteristics arrive on the market). For each household *h* we observe the quantity purchased of each good *i* in each period *t*: $q_t^h = \left(q_{1t}^h, \ldots, q_{it}^h, \ldots, q_{It}^h\right)'$ and we also observe a unit price for each good in each period: $p_t^h = \left(p_{1t}^h, \ldots, p_{it}^h, \ldots, p_{It}^h\right)'$. The total expenditure by household *h* in period *t* is therefore $x_t^h \equiv \left(p_t^h\right)' q_t^h = \sum_{i=1}^{I} p_{it}^h q_{it}^h$. Knowing the technology matrix A and the amount of goods purchased, we can calculate the amount of characteristics purchased.

## 2.1 *The optimisation problem*

The households have preferences for characteristics, and the purchased quantities of goods that we observe are a result of households maximising their utility given the technology, the prices and the budget. In each period, the household therefore faces the problem:

$$
\begin{aligned}
\underset{q_t^h}{Max} \quad & u^h\left(z_t^h \middle| \Omega_t^h\right) \\
s.t. \quad & z_t^h = \mathrm{A}_t' q_t^h \\
& x_t^h \geq \left(p_t^h\right)' q_t^h \\
& q_t^h \geq 0
\end{aligned}
\tag{3}
$$

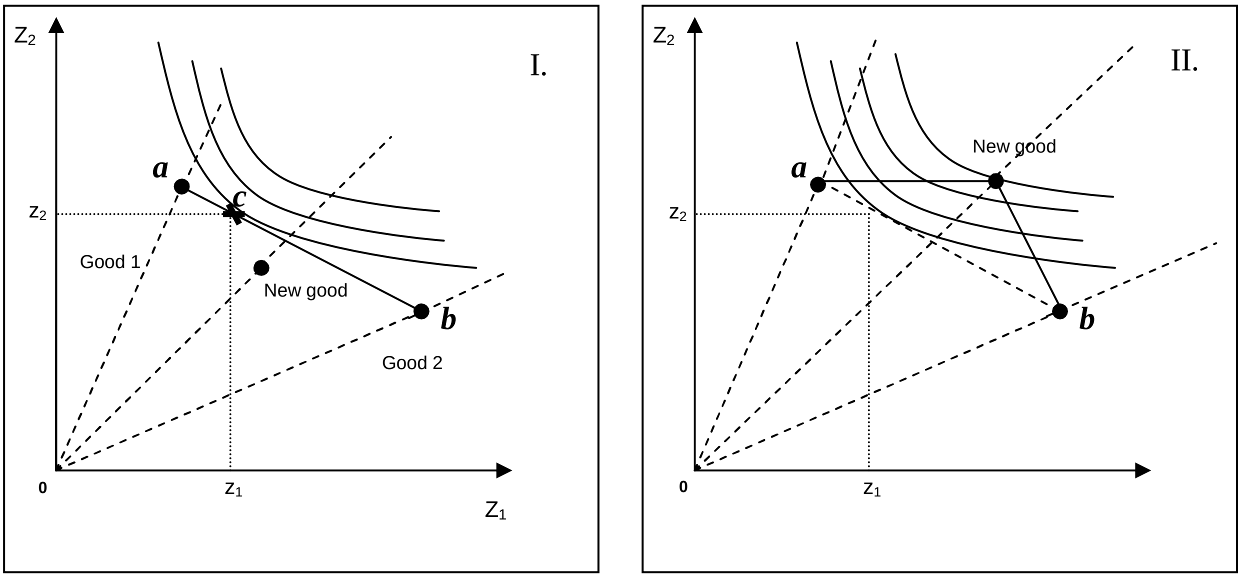
where $\Omega_t^h$ are socio-demographic characteristics and $x_t^h$ is the total budget used by household *h* at time *t.* Note that the household maximises utility by choosing bundles of goods *q*, but obtains utility from the characteristics *z* inherent in the goods. This is because consumers purchase goods, but consume characteristics.

In a world with two characteristics, the consumers' problem can be shown visually. Knowing the prices *p* and the total amount spent[1] *x*, we can calculate the amount of each characteristic $(z_1, z_2)$ that household *h* would obtain in period *t* if all the money was spent on good one (point *a* in Figure 1.I below). If he spent all his money on good 2, he would obtain another amount of characteristics (point *b*). We assume that all goods can be purchased in continuous quantities. This means that any linear combination of goods 1 and 2 is possible, and the line between the highest obtainable levels of characteristics (point *a* and point *b*) is therefore the budget restriction, also known as the '*efficient front*' in characteristics models. When a new good, with known characteristics, but in new amounts, enters the market, the price of that good determines whether it will be purchased or not. In Figure 1.I, the price of the new good is too high (the consumer would get less of the characteristics $z_1$ and $z_2$ if he bought the new good), while in Figure 1.II, the price of the new good is low enough to push the budget constraint outwards and the consumers can obtain their preferred mix of

[1] In theory, we need to know the amount available for consumption. However, this amount cannot be observed, so we have to assume that the budget constraint is binding and use the observed amount actually spent.

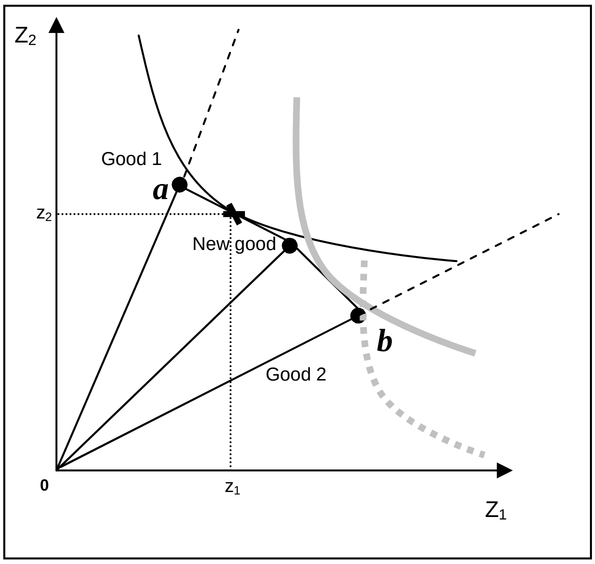
characteristics cheaper by buying the new good than by mixing good 1 and good 2.

**Figure 1 Consumers' optimisation problem in a two characteristics world**




More goods exist in the world than are purchased by the individual household. For another household, it might be more efficient to purchase a mix of the new good and good 2 as shown in Figure 2. Due to the technology restriction, in figure 1.I with only two goods, it is not possible to purchase characteristics outside the triangle $(a, b, 0)$. This makes it difficult to point identify the parameters of the utility function for households who only purchase a good on the borderline, as e.g. the grey stipulated household in Figure 2. We will return to this later.

**Figure 2 More consumers in a two goods, two characteristics world**




### *2.2 Identification of implicit prices*

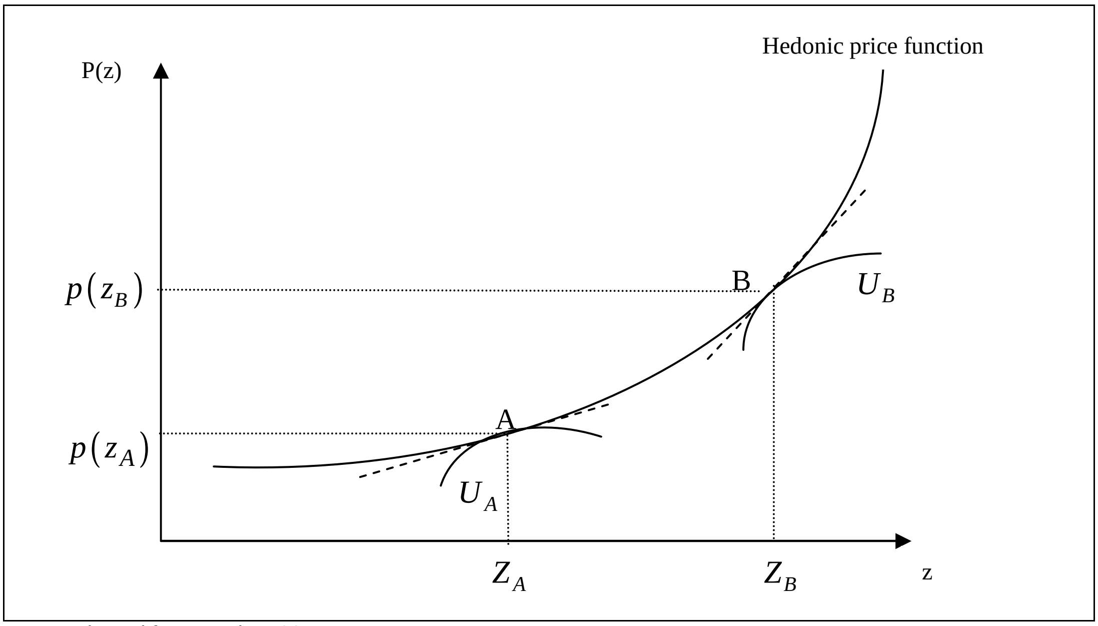
The implicit prices $\pi$ measure how much money the household is willing to pay for an extra unit of characteristic *j*, $\left(\pi = \partial x / \partial z\right)$. If there are more goods than characteristics, these implicit prices have to be estimated using a hedonic price function, see e.g. Rosen (1974), Ladd and Zober (1977) or Ladd and Suvannunt (1976). In a world with *J* characteristics optimised over *I* goods, the first-order conditions mean that:

$$\frac{\partial u}{\partial q_i} - \frac{\partial u}{\partial x} p_i = \sum_{j=1}^{J} \frac{\partial u}{\partial z_j} \frac{\partial z_j}{\partial q_i} - \frac{\partial u}{\partial x} p_i = 0$$
$$\Updownarrow \tag{4}$$
$$p_i = \sum_{j=1}^{J} \frac{\partial u}{\partial z_j} \frac{\partial x}{\partial u} \frac{\partial z_j}{\partial q_i} = \sum_{j=1}^{J} \frac{\partial u}{\partial z_j} \frac{\partial x}{\partial u} a_{ij} = \sum_{j=1}^{J} \frac{\partial x}{\partial z_j} a_{ij}$$

The derivatives $\partial z_j / \partial q_i$ are the elements in the technology matrix $a_{ij}$. The marginal utility of the budget $\partial u / \partial x$ is assumed to be constant. This implies that we have to assume homotheticity of the utility function. This assumption is unrealistic for luxury goods or goods with a large share of total consumption, but more realistic for a normal good with a smaller share of total expenditure (like milk). The homotheticity and (4) imply that the price of a good is a weighted sum of the implicit prices of the characteristics of the good, $p_i = \sum_j \pi_j \alpha_{ij}$ , which is one of the most important features of the characteristics model. If $p_i \geq \pi_j \alpha_{ij}$ then good *i* is not bought as illustrated in Figure 1.I.

When implicit prices are used in a model which estimates demand for characteristics, there are several points to consider. Since one DKK spent on food will give you varying amounts of nutrients, dependent on which mixture of foods you choose to buy, the budget constraint in characteristics space is generally nonlinear. This leads to endogenous prices. However, under the assumption of constant returns to scale, prices can be assumed to be exogenous at the optimal point (Deaton and Muellbauer, 1980). Another problem is that consumers choose quantity and price simultaneously as illustrated in Figure 3. This means that the model is unidentified (Ekeland et al., 2004); the implicit prices provide no more information than the preferences originally used to estimate the implicit prices. Brown and Rosen (1982), Kahn and Lang (1988), Eppel (1987) and Ekeland et al. (2004) suggest identification by allowing the price function to have higher powers of *z* (the characteristic) in the case of single market data, or to use multi-market data to solve the identification problem. The main idea behind these identification strategies is that there must be additional parameters affecting the price functions that are not contained in the demand function. The multi-market identification approach, which is used here, builds on the assumption that the preference parameters and the distribution of tastes are identical across markets, but the price functions differ between markets, i.e. are affected by some additional variables not in the demand function. This implies different patterns of variance in different markets.

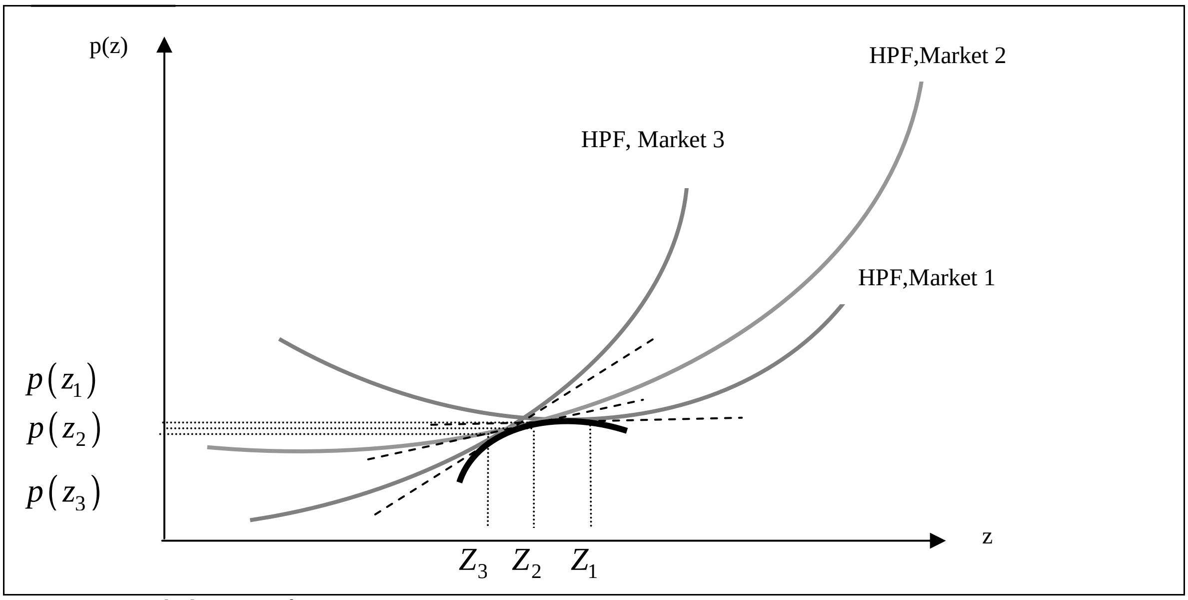
**Figure 3 Simultaneous choice of price and quantity in the hedonic model***




*Adapted from Epple, 1987.

The identification of preferences from variation in the hedonic price functions is illustrated in Figure 4.

**Figure 4 Illustration of identification in the multi-market case**




HPF = hedonic price function.

Despite the fact that the identification problems are solved in the multi-market case, a standard endogeneity problem persists, since the quantity and price of the characteristics are chosen simultaneously. This implies that the dependent variable (the chosen amount of the characteristic) and the implicit price are correlated through their dependence on the distribution of individual heterogeneity (Bartik, 1987; Kahn and Lang, 1988; Diamond and Smith, 1985). We handle the problem of endogenous prices by calculating prices for several sub-markets and by assuming that the prices on these sub-markets are defined by the consumption of other consumers. When defining the different markets, we control for systematic differences in quality caused by, e.g. different production methods. There may, however, still be unobserved differences in quality which can lead to an imperfect price – quality relation, which will be captured by the error term of the estimated pricefunction. The estimation of the implicit prices is unbiased as long as the unobserved quality is uncorrelated with the variables we use to define the separate markets. We expect our market structure to capture such systematic differences.

## 3 Data and the milk market

### *3.1 Purchase data and background data*

In the empirical estimations, we use a comprehensive panel dataset from GfK ConsumerTracking Scandinavia (a marketing institute with branches all over the world). The data cover the period from 1997 to 2004 and include information about daily purchases for individual households. Additionally, a wide range of social and demographic questions about the households (income, location, media habits, favourite store etc.) and information about each individual in the household (BMI, exercise habits, education, age etc.) are posed annually. These purchase data are combined with nutrition data such as the content of fat, protein, calcium etc. for each type of milk. This means that whenever a household purchases milk, we know the equivalent bundle of nutrients purchased.[2] The milk purchase data are observed on a daily (or even hourly) basis, but we choose to aggregate to monthly observations in order to minimise the amount of zeros in the

[2] For a thorough description of the data, see Andersen and Smed (2008) or Smed (2008).

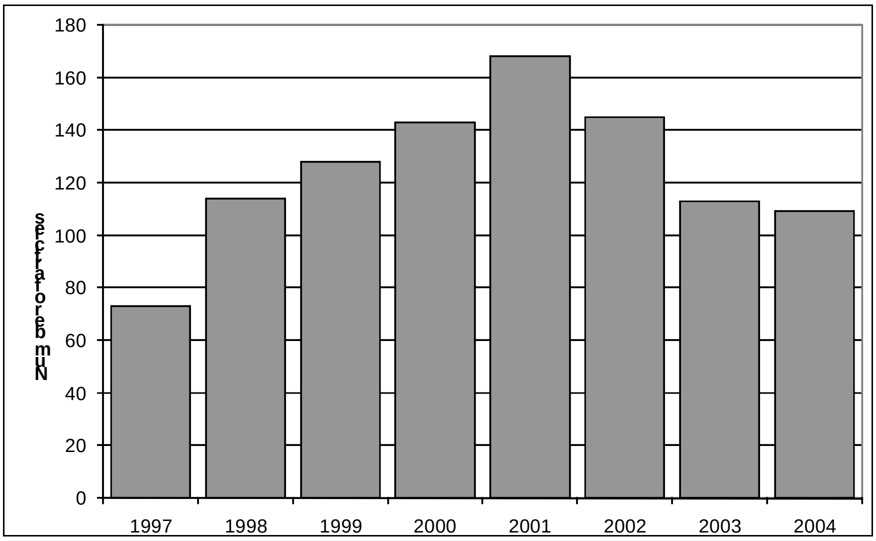
dataset. This also makes the inter-temporally separable model which we use more appropriate since milk is a non-durable good.[3] On average, 1,700 households reported purchases of milk during a month in the period 1997 to 2004. In the estimations, we only use households who reported for at least 24 months during this period, and the average number of households which reported in a month is therefore only 1,347. On average, the households reported purchases of milk during 27 months of the eight year period, while in the restricted data used in the estimations, the average was 58.5 months out of a possible 96.

### *3.2 Information data*

Consumers receive information about the connection between health and the intake of fat through various channels. Most studies, which incorporate the effect of health information on food demand, use proxies to account for the amount of information that consumers receive. The most direct approach uses the number of relevant newspaper articles and/or the number of television transmissions (e.g. Piggott and Marsh, 2004; McGuirk et al., 1995; Schmidt and Kaiser, 2004; Verbeke and Ward, 2001; Smith et al., 1988). This approach is used here, and the number of articles which mention a link between the intake of fat and health was therefore collected from Danish newspapers. The basic search words were fat/fat-rich/low fat in connection with health, slim, overweight, obesity which resulted in 12 different combinations of searches. The articles were aggregated over newspapers independently of the size or location of the article. As presented in Figure 5, the number of articles increased steadily until 2001 from which point it decreased.

[3] In Denmark, Milk only keeps fresh for a little longer than a week. The market for UHT milk is minimal in Denmark and almost all households buy and consume fresh milk.

**Figure 5 Absolute number of hits in newspapers about the link between consumption of fat and health**




Source: Authors' counting based on the search words fat/fat-rich/low fat in connection with health, slim, overweight, obesity in the Infomedia database.

Several of the indices introduced in the literature use a lag structure, as they find that press coverage has a cumulative effect. This includes simple cumulative indices, as in McGuirk et al. (1995) and Schmidt and Kaiser (2004), declining shares to lagged index values, as in Rickertsen et al. (1995), or more sophisticated structures as in Verbeke and Ward (2001). Based on the literature, we chose to let the information last for a three-month period.[4]

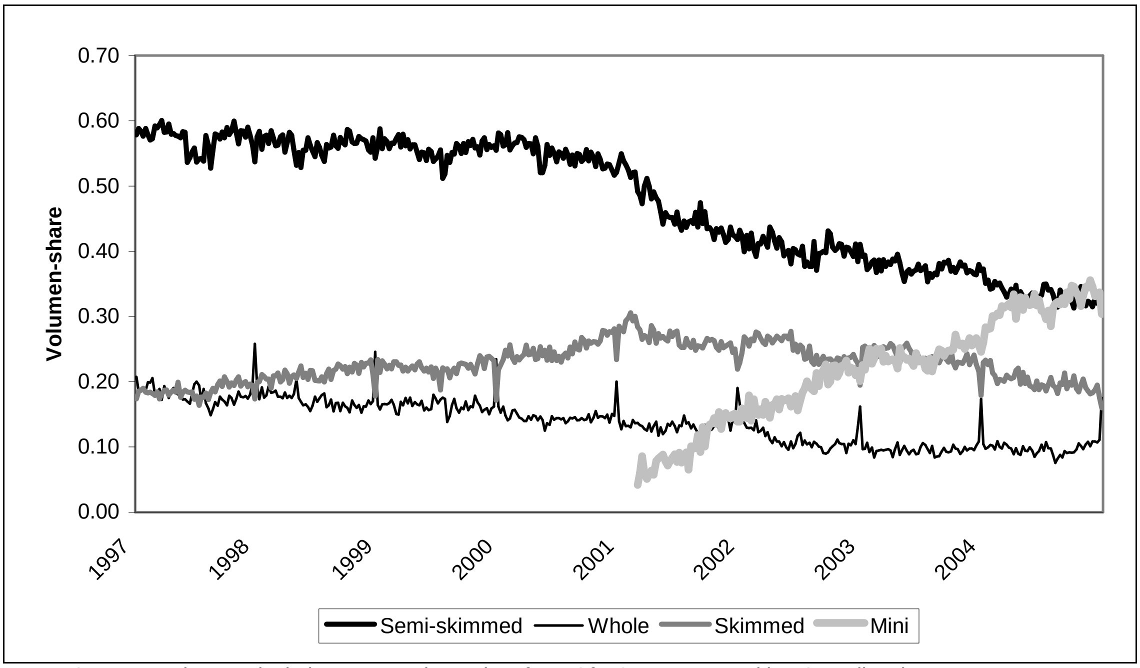
### *3.3 The milk market*

Until February 2001, there were four major types of milk on the Danish market: Whole milk, semi-skimmed milk, skimmed milk and buttermilk. Buttermilk is not included in the analysis because it is sour and is therefore not a direct substitute for the non-sour milk types. Whole milk has a fat content of 3.5 percent; semi-skimmed milk of 1.5 percent and skimmed milk has a fat content of 0.1 percent. In February 2001, a new type of milk (mini milk, with a fat content of 0.5 percent) was introduced on the Danish

[4] We have also tried a cumulative structure with no decay and a current index with no lags, and the three-month structure shows the best result. More sophisticated analyses of the lag structure could be a route for further research.

market. The milk was marketed as having 'the taste of semi-skimmed milk, but the fat of skimmed milk'.[5] This new type of milk took over part of the market for semi-skimmed milk and reversed the increasing trend for skimmed milk, while the trend for whole milk was almost unaffected, as is evident from Figure 6. The total volume of milk purchased was more or less stable during the same time period.

**Figure 6 The Danish milk market, January 1997 to December 2004**




Source: Authors' calculations on purchase data from GfK ConsumerTracking Scandinavia

In Smed (2005) and Smed and Jensen (2004), price elasticities for milk were estimated at an aggregate level both before and after the introduction of mini milk. These elasticities show that, before the introduction of the new type of milk, semi-skimmed and skimmed milk were substitutes. Since the introduction of mini milk, there is no longer any substitution between semi-skimmed milk and skimmed milk, while semi-skimmed is a substitute to mini milk. This is in accordance with the characteristics model.

[5] According to the EU regulations for milk classification, skimmed milk has a fat content of between 0-0.5 percent. Mini milk could therefore be advertised as skimmed milk even though the content of fat was five times as high as in classic Danish skimmed milk.

## 4 Prices

We take prices of goods as given for the individual households, and thereby focus on the demand side, which seems reasonable in the market for foods since the individual consumer's decision cannot affect suppliers in the hedonic model for milk. This is equivalent to the approach in Muellbauer (1974) and Blow et al. (2005), but is in contrast to Rosen (1974) who focuses on both the demand and supply side. The comprehensive dataset that we use allows us to follow individual households over a very long time (up to eight years) so we can deal with individual heterogeneity in the most extreme way by estimating the model individually for each household. Milk is assumed to consist of two characteristics: milkiness and fat.

Milkiness is the part of milk which is present in all four types of milk in the model, i.e. the common characteristic which distinguishes milk from a mixture of calcium and water, i.e. the fact that you can use it in your coffee or on your cereals, etc. One litre of milk contains one unit of milkiness regardless of the type of milk, i.e. milkiness is measured in litres. As the content of protein, carbohydrate and calcium is practically identical in the four types of milk, these characteristics are included in milkiness (Danish Food Composition Databank - ed. 7.01, 2012). The 'fat' characteristic varies between milk types and not only includes the contents of fat in grams, but also the less definable differences such as mouth feel, taste, smell, appearance etc. It is therefore not possible to measure the fat characteristic as precisely as the milkiness. Our best measure is the amount of fat in grams, but it does not perfectly capture the differences between types of milk.

### *4.1 Identification and estimation of prices*

Using observed purchases from all consumers, we estimate hedonic price functions for 18 different markets, assuming that the price structure varies between three types of *stores*: discount stores, supermarkets and other stores, three geographical *regions*: capital area, east and west and two *modes of produce*: organic or conventional. On each of these markets, we control for whether the milk was produced at a standard, discount or luxury dairy, thereby controlling for the most important quality differences.[6] Demand functions are then estimated for the households assuming that they visit several markets, i.e. go into different kinds of stores and buy both conventional and organic milk. This ensures identification, since parameters that do not influence the demand function for the individual consumer, namely other consumers' preferences, influence the hedonic price function.

As our consumer only contributes to a minor degree to each particular hedonic price function, the estimated implicit prices can be assumed to be exogenous. Furthermore, the usual problem of endogeneity does not apply, since each consumer's demand function is estimated individually. Figure 7 shows the empirical version of the efficient front from Figure 1, i.e. how much of each of the characteristics fat and milkiness you receive if you use one DKK on a particular type of milk, on two specific markets defined by type of store, region (Capital) and mode of produce (conventional), both produced at standard dairies.

Figure 7.I shows the efficient front at discount stores and Figure 7.II at supermarkets. The consumption set consists of only three points (skimmed, semi-skimmed and whole milk) for the years 1997 - 2000, while the consumption sets in the following years have four points due to the entrance of mini milk on the market. Similar consumption sets can be constructed for the 16 other markets.

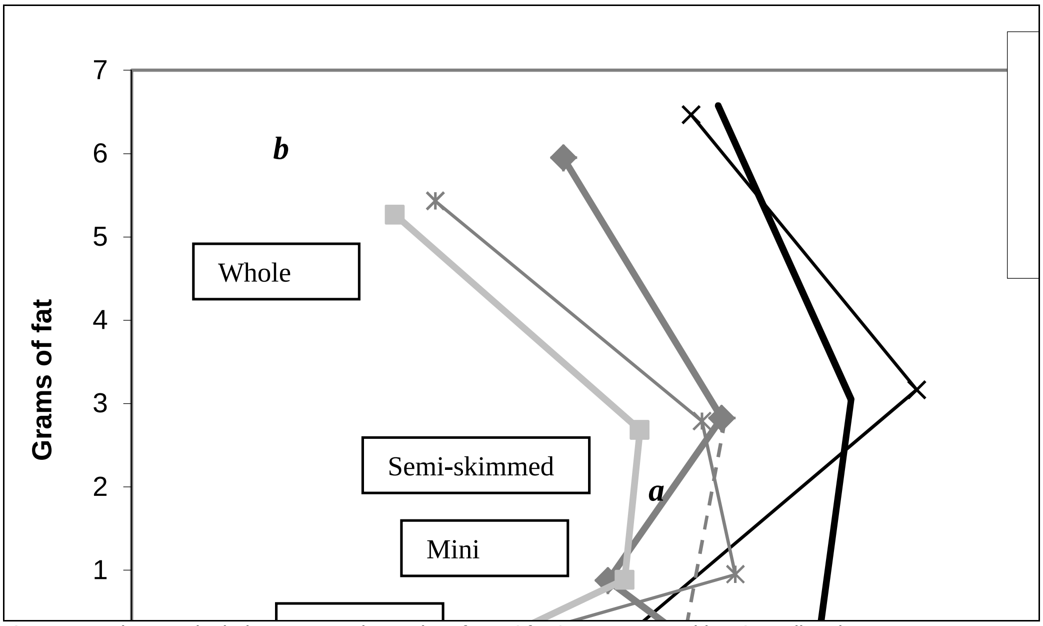
[6] Discount dairies are mainly foreign dairies which produce milk for, e.g. store brands etc. The luxury dairies are local or speciality dairies.

To illustrate the differences between the two markets (discount and supermarkets), consider point *a* in both figures, which indicates the amount of milkiness and fat one obtains by spending 1 DKK on skimmed milk in 1997 in the two different types of stores. More milkiness is obtained by purchasing skimmed milk in a discount store compared to a supermarket, while the amount of fat is approximately the same. Point *b* (whole milk, 2003) shows that both more fat and more milkiness are obtained by spending one DKK on whole milk in a discount store compared to a supermarket.

Figure 7.I and II also show that milk is generally more expensive in supermarkets than in discount stores (the amount of milkiness and fat one can obtain per DKK is lower). Both figures also illustrate that the efficient fronts move towards the origin, which means that the absolute price increased over the period.

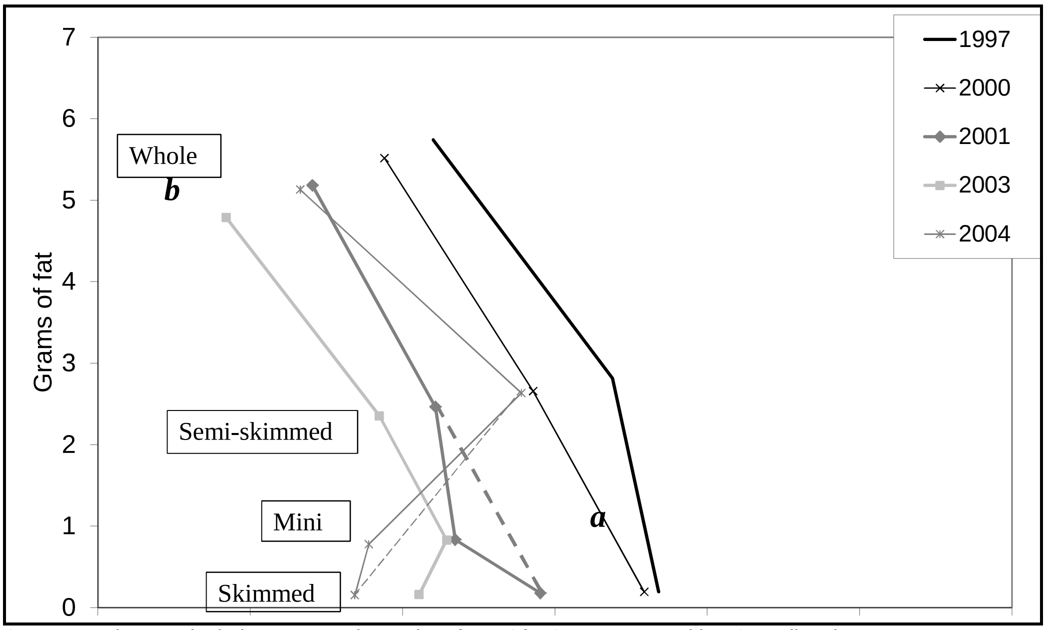
**Figure 7 The empirical efficient front, capital, conventional, standard dairy**

**I: Discount**




Source: Authors' calculations on purchase data from GfK ConsumerTracking Scandinavia
A: Milkiness and fat obtained by spending 1 DKK on *skimmed* milk in *1997* at a *discount* store.
B: Milkiness and fat obtained by spending 1 DKK on *whole* milk in *2003* at a *discount* store.

**II: Supermarket**

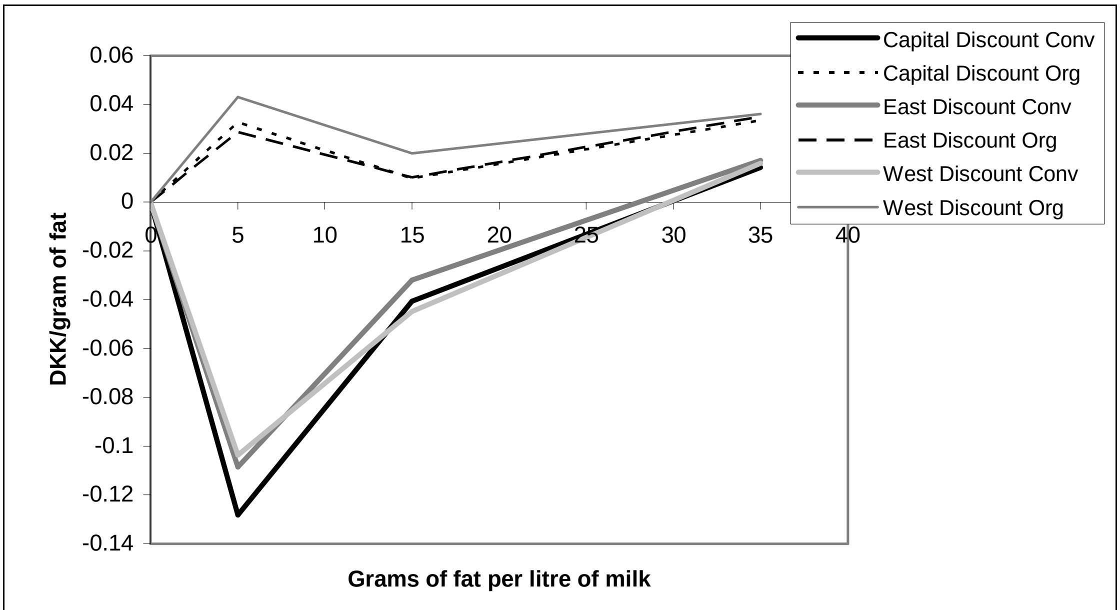



Source: Authors' calculations on purchase data from GfK ConsumerTracking Scandinavia
A: Milkiness and fat obtained by spending 1 DKK on *skimmed* milk in *1997* at a *supermarket*.
B: Milkiness and fat obtained by spending 1 DKK on *whole* milk in *2003* at a *supermarket*.

Figure 7 also shows that in 2001, conventional mini milk was too expensive at discount stores and supermarkets (the efficient consumption set is indicated by the dashed grey lines) and the consumers should not have been buying it. That they did anyway may be because the product was new on the market and was marketed rather heavily.

Figure 8 is a crude illustration of the hedonic price function for fat illustrated for selected markets. The figure illustrates the need for a quadratic form for the hedonic price function and separate markets for organic and conventional. The figure is crude in the sense that the average price of milk is used so the figure does not take the distribution of consumer preferences into account.

**Figure 8 A crude empirical hedonic price function for fat, year 2003, standard dairy, discount stores**




Source: Authors' calculations on purchase data from GfK ConsumerTracking Scandinavia

Prices estimated from average prices of skimmed, mini, semi-skimmed and whole milk. Skimmed milk is the basis and the price of skimmed milk is assumed to reflect the price of milkiness (i.e. the amount of fat in skimmed milk is set to 0 in these figures, which is also a simplification). The price of fat is then calculated as the difference between the price of the milk in question and the price of skimmed milk, since all milk is assumed to contain the same amount of milkiness.

In the demand model, we treat preferences for milk as separable from all other food. Furthermore, we treat preferences for milkiness and fat as separable from the mode of production (organic or conventional) and dairy (standard, discount or luxury dairy). As it appears from Figure 8, the hedonic price function for organic and conventional milk differs, but the hedonic price function for fat is unaffected by the dairy (not shown in the figure). We therefore choose to treat mode of production as a separate market for each kind of store and each region, while dairy appears as a dummy within the hedonic price equation. This means that eighteen different versions of the hedonic price equation (5) are estimated, one for each market (three types of stores, three regions and two modes of production). Equation (5) shows how the price per litre of milk is estimated for each of the eighteen markets, i.e. the $\eta$'s are market specific:

$$\begin{aligned} p_{it} &= \eta_{milkiness,t} + \eta_{luxury\_dairy,t} D_l + \eta_{discount\_dairy,t} D_d \\ &+ \eta_{fat,t} z_{fat,t} + \eta_{fat\_sq,t} \left( z_{fat,t} \right)^2 + \varepsilon_{it} \end{aligned} \tag{5}$$

The constant accounts for the price of one litre of "milkiness" produced at a standard dairy, and with no fat. $D_l$ and $D_d$, are dummies which account for luxury and discount dairy respectively, $z_{fat}$ accounts for the content of fat in grams per litre. The polynomial of second order implies that the price of fat varies with the type of milk and, as illustrated in Figure 8, it is more expensive to obtain fat from whole milk than from semi-skimmed milk. The parameters from this estimation result in a set of monthly implicit prices of characteristics, one for each market.

To construct individual prices for each household, the estimated implicit prices on each market are weighted according to actual purchase patterns on either the organic or the conventional market and in the three different stores.[7]

[7] We assume that the consumer only buys milk in his own region.

## 5 Model specification

### *5.1 Demand under quadratic utility*

We assume a quadratic utility function $u(z) = z'\alpha - 0.5z'\beta z$ in the characteristics milkiness and fat. The quadratic utility has a point with maximum utility (a bliss point) and the possibility of negative marginal as well as absolute utility of characteristics. This makes sense when estimating a model for characteristics. Free disposal is usually possible for goods, but not always for characteristics. It is not possible to dispose of fat without disposing of milkiness, and a positive utility of milkiness may outweigh a negative absolute utility of fat.

To simplify the problem a little, the $\beta$ matrix is assumed to be diagonal. This means that we assume no correlation between the utility of milkiness and fat. In order to normalise the parameters, the alphas are assumed to sum to one. In a two characteristics world, the utility function for household *h* at time *t* is:

$$u\left(z_t^h\right) = z_t^{h\prime}\alpha^h - 0.5z_t^{h\prime}\beta^h z_t^h = \left(1-\alpha_2^h\right) z_{1t}^h + \alpha_2^h z_{2t}^h - 0.5\left(\beta_1^h \left(z_{1t}^h\right)^2 + \beta_2^h \left(z_{2t}^h\right)^2\right) \tag{6}$$

where $z_{1t}^h$ is milkiness measured in litres, and $z_{2t}^h$ is total fat from milk. This means that in optimum we have:

$$\frac{\partial u / \partial z_{1t}^h}{\partial u / \partial z_{2t}^h} = \frac{\left(1-\alpha_2^h\right) - \beta_1^h z_{1t}^h}{\alpha_2^h - \beta_2^h z_{2t}^h} = \frac{\pi_{1t}^h}{\pi_{2t}^h} \tag{7}$$

where $\pi_{1t}^h$ is the price of one litre of milkiness for household *h* in period *t*, and $\pi_{2t}^h$ is the price of one gram of fat for household *h* in period *t*. For each household *h*, and each time period *t*, this is equivalent to:

$$0 = \alpha_2^h - \left(1-\alpha_2^h\right)\frac{\pi_{2t}^h}{\pi_{1t}^h} + \beta_1^h \frac{\pi_{2t}^h}{\pi_{1t}^h} z_{1t}^h - \beta_2^h z_{2t}^h \tag{8}$$

This is called *m*-demand (Browning, 1999), which generally implies that demand for one good is expressed as a function of demand for a reference good. In this particular case, we estimate the demand for fat ( $z_2$ ) and use milkiness ( $z_1$ ) as the reference characteristic. As long as the reference good (or characteristic) is normal, this is a satisfactory measure of utility conditional on prices (*ibid*). The parameters of the utility function ($\alpha$ and $\beta$) are assumed to be household specific and time invariant, whereas both prices $\pi$ and consumption $z$ are allowed to vary over time and between households.

We assume that we do not measure consumption perfectly so a random term is added to the *z*'s.[8] The random terms on the *z*'s are connected by the budget:

$$x_t^h = \pi_{1t}^h\left(z_{1t}^h + \xi_{1t}^h\right) + \pi_{2t}^h\left(z_{2t}^h + \xi_{2t}^h\right) \quad \Leftrightarrow \quad \xi_{1t}^h = \frac{x_t^h - \pi_{1t}^h z_{1t}^h - \pi_{2t}^h\left(z_{2t}^h + \xi_{2t}^h\right)}{\pi_{1t}^h} \tag{9}$$

and we can therefore only identify one error term. We have defined milkiness as the observable identical characteristic of the four types of milk, whereas fat covers not only the contents of fat in grams which is presented on the packaging, but also the quality differences induced by the different fat levels. These quality differences are not perfectly observable, and we therefore use milkiness as the reference good and assume that it is observed perfectly, and assume that fat is observed with uncertainty. Then the *m*-demand in (8) becomes:

[8] We have also estimated a model in which the random term is related to the preferences and therefore added to the alfas (Andersen and Smed 2008). However, the conclusion was that measurement errors worked better.

$$0 = \alpha_2^h - \left(1 - \alpha_2^h\right) \frac{\pi_{2t}^h}{\pi_{1t}^h} + \beta_1^h \frac{\pi_{2t}^h}{\pi_{1t}^h} z_{1t}^h - \beta_2^h \left(z_{2t}^h + \xi_{2t}^h\right) \tag{10}$$

### *5.2 Including trend and information in the specification*

A trend is introduced in the model in order to catch general changes in preferences over time. The trend is made exponential and added to the alpha parameter.[9]

We also model the influence of information as additive to the alpha parameter, which implies that both information and trend decrease the marginal utility of fat regardless of how much fat is consumed. We do not include the trend and the information in the normalisation $\left(\alpha_1 + \alpha_2 = 1\right)$. This means that the utility function in equation (6) becomes:[10]

$$U\left(z_1, z_2\right) = \left(1 - \alpha_2^h\right) z_{1t}^h + \left(\alpha_2^h + \tau_2^h \ln\left(t\right) + \gamma_2^h I\right) z_{2t}^h - 0.5\left(\beta_1^h \left(z_{1t}^h\right)^2 + \beta_2^h \left(z_{2t}^h\right)^2\right) \tag{11}$$

and that the *m*-demand from (10) becomes:

$$0 = \left(\alpha_2^h + \tau_2^h \ln\left(t\right) + \gamma_2^h I\right) - \left(1 - \alpha_2^h\right) \frac{\pi_{2t}^h}{\pi_{1t}^h} + \beta_1 \frac{\pi_{2t}^h}{\pi_{1t}^h} z_{1t}^h - \beta_2^h \left(z_{2t}^h + \xi_{2t}^h\right) \tag{12}$$

### *5.3 Instrumenting the reference characteristic*

We know that $z_1$ is endogenous due to the correlation between milkiness and fat through the budget and we choose to instrument by the lagged value of milkiness and the total budget for drinkable dairy products. We assume that households divide their total budget for food consumption into a part which is related to dairy products, and a part which is not. Once this is done the household decides which fraction of the dairy budget should be spent on the

[9] We have also tried models without a trend and with either a linear or a quadratic trend. The exponential trend showed the best result.

[10] Due to the stability of total consumption of milk and to save on degrees of freedom, we choose here to formulate the model with only a trend on fat.

sub category *drinkable* dairy products. The drinkable dairy products consist of the non-flavoured milk which is included in our model, and types of milk with radically different tastes (buttermilk, chocolate milk, flavoured milk). We use the budget for drinkable dairy products as an instrument because this budget is decided before deciding the sub budget for non-flavoured milk. We also use the lagged consumption of milkiness, assuming that the random error terms influencing actual purchases in every month are not correlated over time. A valid instrument should be relevant (correlated with the endogenous variable) and exogenous (only correlated with the dependent variable through the endogenous variable). The relevance has been tested, and the instruments are jointly relevant at the five percent level for 85 percent of the households.[11] The exogeneity is fulfilled if the overall drinkable dairy budget is decided before the milk budget and if the error terms in consumption over time are uncorrelated as argued above. The instrumentation is done for each household individually:

$$z_{1t}^h = \eta_1^h z_{1t-1}^h + \eta_2^h \tilde{x}_t^h + \zeta_{1t}^h \quad \Rightarrow \quad \hat{z}_{1t}^h = \eta_1^h z_{1t-1}^h + \eta_2^h \tilde{x}_t^h \tag{13}$$

where $z_{1t-1}^h$ is the lagged value of $z_{1t}^h$ and $\tilde{x}_t^h$ is the amount spend on drinkable dairy products. We use the control function approach (Blundell and Powel, 2003), which means that we include both the estimated value $\hat{z}_{1t}^h$ and the residual $z_{1t}^h - \hat{z}_{1t}^h$ in the estimations. Equation (12) then changes to:

$$0 = \left(\alpha_2^h + \tau_2^h \ln(t) + \gamma_2^h I\right) - \left(1 - \alpha_2^h\right)\frac{\pi_{2t}^h}{\pi_{1t}^h} + \beta_1^h \frac{\pi_{2t}^h}{\pi_{1t}^h}\hat{z}_{1t}^h + \delta^h \frac{\pi_{2t}^h}{\pi_{1t}^h}\left(z_{1t}^h - \hat{z}_{1t}^h\right) - \beta_2^h\left(z_{2t}^h + \xi_{2t}^h\right) \tag{14}$$

## 5.4 *Empirical identification*

Equation (14) can be rearranged to:

[11] As we estimate the model household by household the test is likewise performed for each household individually

$$z_{2t}^{h} = \frac{\alpha_2^h + \tau_2^h \ln(t) + \gamma_2^h I}{\beta_2^h} - \frac{(1-\alpha_2^h)}{\beta_2^h}\frac{\pi_{2t}^h}{\pi_{1t}^h} + \frac{\beta_1^h}{\beta_2^h}\frac{\pi_{2t}^h}{\pi_{1t}^h}\hat{z}_{1t}^h + \frac{\delta^h}{\beta_2^h}\frac{\pi_{2t}^h}{\pi_{1h}^h}\left(z_{1t}^h - \hat{z}_{1t}^t\right) + \xi_{2t}^h \quad (15)$$

which empirically can be estimated as:

$$z_{2t}^h = \omega_1^h + \omega_2^h \ln(t) + \omega_3^h I + \omega_4^h \frac{\pi_{2t}^h}{\pi_{1t}^h} + \omega_5^h \frac{\pi_{2t}^h}{\pi_{1t}^h} z_{1t}^h + \omega_6^h \frac{\pi_{2t}^h}{\pi_{1t}^h}\left(z_{1t}^h - \hat{z}_{1t}^h\right) + \xi_{2t}^h \quad (16)$$

where $\omega_1^h = \alpha_2^h / \beta_2^h$, $\omega_2^h = \tau_2^h / \beta_2^h$, $\omega_3^h = \gamma_2^h / \beta_2^h$, $\omega_4^h = -(1-\alpha_2^h)/\beta_2^h$, $\omega_5^h = \beta_1^h / \beta_2^h$ and $\omega_6^h = \delta^h / \beta_2^h$ .

Note that $\omega_4^h = -(1-\alpha_2^h)/\beta_2^h = \omega_1^h - 1/\beta_2^h \Leftrightarrow 1/\beta_2^h = \omega_1^h - \omega_4^h$

$\omega_4 = -(1-\alpha_2)/\beta_2 = \omega_1 - \beta_2^{-1} \Leftrightarrow \beta_2^{-1} = \omega_1 - \omega_4$, which means that the relationships are:

$$\begin{aligned} \alpha_1^h &= \frac{\omega_4^h}{\omega_1^h - \omega_4^h}, \quad \alpha_2^h = \frac{\omega_1^h}{\omega_1^h - \omega_4^h}, \quad \beta_1^h = \frac{\omega_5^h}{\omega_1^h - \omega_4^h}, \quad \beta_2^h = \frac{1}{\omega_1^h - \omega_4^h} \\ \tau_2^h &= \frac{\omega_2^h}{\omega_1^h - \omega_4^h}, \quad \gamma_2^h = \frac{\omega_3^h}{\omega_1^h - \omega_4^h}, \quad \delta^h = \frac{\omega_6^h}{\omega_1^h - \omega_4^h} \end{aligned} \quad (17)$$

The equation can of course also be estimated with $z_1^h$ as the dependent variable. The identification issues are equivalent.

### *5.5 Tobit with two sided censoring*

It is not possible to buy a litre of milkiness without buying at least one gram of fat (skimmed milk), and it is not possible to purchase more than 35 grams of fat per litre of milkiness (whole milk). These restrictions mean that the analytical *m*-demand in (16) cannot always be obtained. Households that have preferences for milk with less fat than skimmed milk and households that have preferences for milk with more fat than whole milk are censored. This problem is solved by estimating a Tobit model with two-sided censoring (Amemiya, 1984; Tobin, 1958). As the model is estimated for each household individually, the actual equation to estimate with instruments (see equation (16)) becomes:

$$z_{2t}^h = \omega_1^h + \omega_2^h \ln(t) + \omega_3^h I_t + \omega_4^h \frac{\pi_{2t}^h}{\pi_{1t}^h} + \omega_5^h \frac{\pi_{2t}^h}{\pi_{1t}^h} \hat{z}_{1t}^h + \omega_6^h \frac{\pi_{2t}^h}{\pi_{1t}^h} \left( z_{1t}^h - \hat{z}_{1t}^h \right) + \xi_{2t}^h \quad (18)$$

$$z_{1t}^h \le z_{2t}^h \le 35 z_{1t}^h$$

After estimating the parameters, we then predict the consumption of fat both in the estimation period and in the prediction period by ignoring the effect of the residual and using the true value of $z_{1t}^h$ instead of the instrumented variable:

$$\hat{z}_{2t}^h = \omega_1^h + \omega_2^h \ln(t) + \omega_3^h I_t + \omega_4^h \frac{\pi_{2t}^h}{\pi_{1t}^h} + \omega_5^h \frac{\pi_{2t}^h}{\pi_{1t}^h} z_{1t}^h \quad (19)$$

We then calculate the predicted milkiness from this and the budget and prices:

$$\hat{z}_{1t}^h = \frac{x_t^h - \pi_{2t}^h \hat{z}_{2t}^h}{\pi_{1t}^h} \quad (20)$$

*The bliss point*

The estimated parameters give a range of possibilities to investigate household preferences for fat. One of the features of a quadratic utility function is that it is possible to calculate the preferred amount of fat and milkiness that would be purchased if all prices were zero (i.e. the bliss point). If $\beta$ is diagonal, the bliss point for each household *h* and each time period *t* can be calculated from (11) as:

$$z_{1t}^{h*} = \frac{\alpha_1^h}{\beta_1^h} \quad \text{and} \quad z_{2t}^{h*} = \frac{\alpha_2^h + \tau_2^h \ln(t) + \gamma_2^h I_t}{\beta_2^h} \quad (21)$$

Where $z_{1t}^h$ is milkiness and $z_{2t}^h$ is fat, both purchased by household *h* at time *t*. The optimal share of fat can then be calculated from (21):

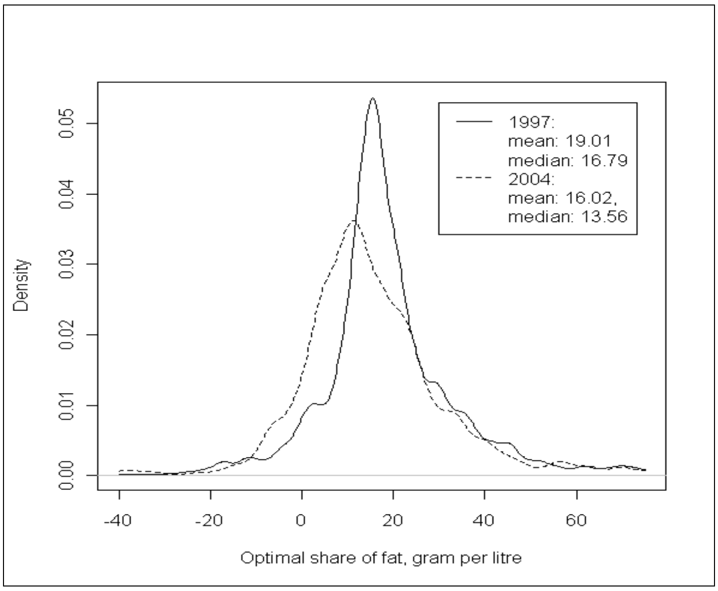
$$\frac{z_{2t}^{h*}}{z_{1t}^{h*}} = \frac{\left(\alpha_2^h + \tau_2^h \ln(t) + \gamma_2^h I_t\right)\beta_1^h}{\alpha_1^h \beta_2^h} \tag{22}$$

## 6 Results

The structural parameters which can be derived from equation (16) are estimated for each of the 1,415 households in the sample and the results therefore cannot be presented in a simple table. We therefore present the distribution of some of the parameters, and test for significant correlations.

Both the optimal fat and the optimal share of fat are changing over time due to the influence of the trend and information. Figure 9 shows the development in the density of the predicted optimal share of fat from 1997 to 2004. The preferences for fat seem to have decreased over the period.

**Figure 9 Optimal share of fat, 1997 and 2004**




Source: The distribution is calculated as a kernel regression with Gaussian kernel (see e.g. Blundell and Duncan, 1998).

In the following, we investigate the relationship between the optimal share of fat and various socio-demographic variables in order to give a more precise picture of the consumption patterns of Danish consumers. We would also like to know whether information or prices could be used to regulate the consumption of fat from milk. Therefore, in the next sub-section, we also investigate whether the own price elasticity for fat[12] and the effect of information about the negative health effects of fat varies with the optimal amount of milkiness and share of fat.

To obtain more reliable results, only households which buy more than one type of milk more than 30 percent of the time (1,415 households) are used in the estimations below. We also impose the restriction that the observations used must have positive optimal milkiness value, because households with negative optimal milkiness value could just as easily have obtained their dairy fat from buying other types of dairy goods since they do not value the milkiness characterstics (1,276 of the 1,415 households have positive optimal milkiness value at some point in time). In order to minimise the effect of outliers, we also require the optimal milkiness per person per week to be less than 13 litres, the optimal share of fat to be between -100 and 100 grams per litre and both the own price elasticity of fat and the parameter information to be between -1 and 1. This gives us a sample of 67,139 observed purchases from 1,160 households. When estimating on the basis of these purchases, households which report purchases in many months are given more weight than households which only participate during the minimum 24 months. Only 5 percent of the 1,160 households have less than 24 observations, half have more than 53 observations, while the average is 58.5 observations per household. Section 6.1 below focuses on socio-demographic differences in consumption, while section 6.2 focuses on price elasticities and reactions to information.

[12] The own price elasticity shows how the consumption of a product is expected to change (measured in percent) if the price of the product increases by one percent. In this case, the ‘product’ is the characteristic, fat. The derivation of the own price elasticities for milkiness and cross-price elasticities between milkiness and fat are shown in Andersen and Smed (2008), appendix B .

### 6.1 *Valuation of fat over time and for various social and demographic groups*

It is useful to know the socio-demographic characteristics of target groups especially for marketing strategies, but also when designing public campaigns which aim to reduce the intake of saturated fat. This knowledge is also important when evaluating which groups of the population will be affected by different types of interventions by the authorities. In the following, we test whether the optimal share of fat varies systematically between households with different consumption levels and households with different socio-demographic statuses.

**Table 1 Optimal share of fat explained by socio-demographics**

| Explanatory variable | Param. Est. | St. Err. | Pr > \|t\| | F test |
|---|---|---|---|---|
| Intercept | 14.84 | 0.254 | <.0001 | |
| Time[a] | -1.70 | 0.230 | <.0001 | |
| Optimal milkiness per person[b] | -2.61 | 0.047 | <.0001 | |
| Dummy for men 21 yrs or older in household | 1.74 | 0.157 | <.0001 | |
| Dummy for kids 3 yrs or younger in household | 1.30 | 0.274 | <.0001 | |
| Age of the main shopper[c] | 0.15 | 0.005 | <.0001 | |
| OECD weighted household income[d] | -0.28 | 0.041 | 0.0002 | |
| *Education of the main shopper, 3 years or less of non-vocational higher education, (short) is control group* | | | | |
| None or vocational further education (low) | 1.83 | 0.191 | <.0001 | *Low = long: 0.0343* |
| Medium or long non-vocational higher educ. (3 years or more) (long) | 2.22 | 0.237 | <.0001 | |
| *Urbanisation, city municipality is control group[e]* | | | | |
| Lives in a rural municipality | 2.45 | 0.144 | <.0001 | *Rur = cap: <.0001* |
| Lives in the capital area | 0.76 | 0.165 | <.0001 | |
| *Number of observations* | *67.139* | | | |
| *$R^2$* | *7.61 %* | | | |
| *Adjusted $R^2$* | *7.60 %* | | | |

Source: OLS regression on parameters for preferences for fat in milk obtained through estimation of a structural characteristics model on observed purchases from GfK ConsumerTracking Scandinavia. Dependent variable: optimal share of fat, measured in grams per litre.
a: The trend has been normalised so that a change of 1 corresponds to a change of 96 months, i.e. the difference from the beginning of the estimation period to the end of the estimation period.
b: The optimal milkiness per person is measured in litres and rescaled so that 1 litre per person becomes the control group.

c: The age of the main shopper is measured in years and rescaled so that the age 50 becomes the control group.
d: Income is recorded in brackets of DKK 50,000 (~€6,700). These brackets are divided by the number of individuals in the household, weighted by the OECD-modified scale, i.e. 1 for the first adult, 0.5 for each additional adult and 0.3 for each child (OECD, 2009). The value is rescaled so that the median value becomes the control group.
e: The 271 Danish municipalities from before the municipal reform are divided into rural, city and capital municipalities by the proportion of households living in urban settlements. A household may live in the countryside of a city municipality, but the probability of living in the countryside is less than for households living in a rural municipality.

Table 1 shows the results of a linear model, regressing the household specific optimal share of fat on a general trend, as well as the socio-demographic characteristics of the households and of the individuals who are mainly responsible for shopping (the main shoppers). We use the age and the education of the main shopper because we believe that this individual also makes most of the decisions regarding which type of milk to purchase.[13]

The results show that, in the beginning of 1997, the average household in the control group[14] preferred a fat share of 14.84 grams per litre (which almost perfectly corresponds to semi-skimmed milk which contains 15 grams of fat per litre). During the eight year period from the beginning of 1997 to the end of 2004, the average optimal fat share decreased by 1.70 grams per litre. This means that, during the period 1997 to 2004, there was a general fall in preferences for fat in milk.

The parameter for optimal milkiness per person shows that households which would prefer more than one litre of milk per person per week, generally had a lower optimal share of fat (2.61 grams fat less per litre extra milkiness). This means that households with a high consumption of milk generally prefer lighter types of milk, and that households which prefer

[13] We have also estimated the model using the average age of the adult persons in the household, and using the highest level of education within the household, but the results are essentially the same as the one presented here.

[14] The control group consists of households with optimal amount of milk per person per week equal to 1 litre; no men older than 21 years in the household; no children three years or younger in the household; short non-vocational education of the main shopper; living in a city municipality; main shopper 50 years of age and a household income at the median.

heavy milk types generally consume less milk, which decreases the negative effect of the high share of fat.

Both the presence of adult males and children three years or younger increase the optimal share of fat (by 1.74 for men, 1.30 for children). This was expected for children because they are recommended to drink milk with a higher content of fat until they reach the age of three. The parameter for the presence of men in the household can both be interpreted as if men generally have higher preferences for fat, or as if single women have stronger preferences for avoiding fat than women who have a spouse.

The parameter for age is positive (0.15 per year), which means that if the main shopper is older, the optimal share of fat will be higher than if the main shopper is younger. This could either be because of habits formed at a time when fat was not an issue (a cohort effect), or because the preference for fat in milk increases with age (an age effect). This could be an interesting topic for research in a longer panel.

The parameter for OECD-modified household income (see note d in Table 1) is negative, which means that households with high income tend to have a lower optimal share of fat than people with lower levels of household income, even when controlling for the education of the main shopper. For a single person, an increase of one unit in OECD-modified household income means, in our case, an increase in annual income of €6,700 and thereby a decrease in optimal share of fat of 0.28 grams per litre.

When it comes to education, the lowest optimal share of fat is found for households in which the main shopper has a short non-vocational education, and the highest for households in which the main shopper has more than three years of non-vocational higher education. The F test shows that the difference between main shoppers with no education or vocational education and main shoppers with more than three years of non-vocational higher education is significantly different from zero at the five percent level.

The parameters for degree of urbanisation show that households which are located in city municipalities have the lowest optimal share of fat, and that households which are located in rural municipalities have a significantly higher optimal share of fat compared to households which are located in a city municipality or in the capital area, again a result where the lowest share of fat is found between the two extremes, and where the two extremes are also significantly different from each other (this time at the 0.1 percent level).

### *6.2 Political implications – who may be affected by prices and information*

It is of great interest to investigate whether the price elasticity or the information parameter varies with optimal milkiness per person per week and with optimal share of fat. In order to obtain a more precise picture of the variation among consumer types, we have created dummies for different intervals of optimal share of fat, corresponding to the milk types actually available on the Danish market during the period (skimmed milk, 1 gram of fat per litre; mini milk, 5 grams of fat per litre; semi-skimmed, 15 grams of fat per litre and whole milk, 35 grams of fat per litre).

Table 2 shows how the estimated information parameters vary with optimal consumption of milkiness and optimal share of fat, again divided into five categories. All the estimated effects are significantly different from each other.

**Table 2 Reaction to information explained by optimal milkiness per person per week and optimal share of fat divided into five categories**

| Explanatory variable | Param. Est. | St. Err. | Pr > \|t\| |
|---|---|---|---|
| Optimal milkiness per person[a] | 0.01 | 0.000 | <.0001 |
| *Dummies for:* | | | |
| Optimal share of fat less than 0 | -0.10 | 0.001 | <.0001 |
| Optimal share of fat more than 0 and less than 5 | -0.04 | 0.001 | <.0001 |
| Optimal share of fat more than 5 and less than 15 | -0.03 | 0.001 | <.0001 |
| Optimal share of fat more than 15 and less than 35 | -0.01 | 0.001 | <.0001 |
| Optimal share of fat more than 35 | 0.01 | 0.001 | <.0001 |
| *Number of obs.* | *67,903* | | |
| $R^2$ | *12.64%* | | |
| *Adjusted* $R^2$ | *12.63%* | | |

Source: OLS regression on parameters for the effect of 100 extra newspaper articles about the negative health effects of fat obtained through estimation of a structural characteristics model on observed purchases from GfK ConsumerTracking Scandinavia.
Dependent variable: Information, estimated effect of 100 newspaper articles about the negative health effects of fat.
a: The optimal milkiness per person is measured in litres.

The effect of information about the negative effects of fat is expected to be negative, i.e. the negative newspaper articles are expected to make households reduce their consumption of fat. This is also the case for four of the fat share categories, but not for the fat lovers (who would prefer milk with more fat than whole milk), who have a relatively small but positive reaction to negative information. The table also shows that households with a high preference for milkiness are less likely to react to information (the parameter for optimal milkiness per person is positive), which means that information does not affect these households. When comparing the different fat share categories, it becomes clear that the effect of information decreases as the preference for fat increases, and the strongest reaction is found among the fat haters. This means that information mainly affects the households which already have a preference for low fat milk, but misses the group of fat-loving households. All in all, it seems as though information is not a very efficient way of reducing the total consumption of fat from milk.

Table 3 shows how the estimated own price elasticities for fat[15] vary with optimal consumption of milkiness and optimal share of fat, again divided into five categories. Again, all the estimated effects are significantly different from each other.

**Table 3 Estimated own price elasticity for fat, explained by optimal milkiness per person per week and optimal share of fat divided into five categories**

| Label | Param. Est. | St. Err. | Pr > \|t\| |
|---|---|---|---|
| Optimal milkiness per person[a] | 0.01 | 0.001 | <.0001 |
| *Dummies for:* | | | |
| Optimal share of fat less than 0 | 0.00 | 0.003 | 0.1159 |
| Optimal share of fat more than 0 and less than 5 | -0.03 | 0.003 | <.0001 |
| Optimal share of fat more than 5 and less than 15 | -0.14 | 0.002 | <.0001 |
| Optimal share of fat more than 15 and less than 35 | -0.23 | 0.001 | <.0001 |
| Optimal share of fat more than 35 | -0.28 | 0.003 | <.0001 |
| *Number of obs.* | *67,903* | | |
| *$R^2$* | *43.20%* | | |
| *Adjusted $R^2$* | *43.19%* | | |

Source: OLS regression on parameters for the effect of 100 extra newspaper articles about negative health effects of fat obtained through estimation of a structural characteristics model on observed purchases from GfK ConsumerTracking Scandinavia.
Dependent variables: Estimated own price elasticity for fat
a: The optimal milkiness per person is measured in litres.

Just as for information, the parameters are expected to be negative, because an increase in price is expected to cause a decrease in consumption. The only positive parameter in Table 3 is the one for optimal milkiness, which means that households with a high consumption of milk are less likely to react to changes in prices. This indicates that strong preferences for milkiness make milk a necessity good. Contrary to information the effect of price increases with optimal share of fat, ranging from insignificant for the fat haters to -0.28 for the fat lovers. Fat haters would prefer milk with a negative content of fat, but as this is not available, they purchase skimmed

[15] The price elasticity is a nonlinear function of the price of the milkiness characteristic and the fat characteristic, and of the budget for the entire purchase. We have chosen to calculate elasticities for each observed purchase and then to investigate the average elasticity per household. This reduces the noise from the variation in prices and budget.

milk instead (they are at the edge of the possible consumption set). The price inelasticity of the fat haters means that the prices of the other types of milk would have to change radically to make these types of milk attractive to the fat-haters. More interesting is the fact that the fat-lovers, who are also on the edge, but at the other end of the possible consumption set, are rather influenced by prices. This means that increasing the price of fat could be an effective way of reducing consumption of fat from milk.

## 7 Conclusion and discussion

The market for milk is suitable for economic analysis since almost all Danish households purchase milk and the characteristics inherent in milk are well defined. During our data period, there was a significant decrease in the consumption of fat from milk without any particular decrease in the total consumption of milk. This decrease was due to both changing preferences for fat and the entrance of a new low-fat variety of milk. In this paper, the demand for fat in milk has been analysed in a structural characteristics model for milk. Estimating a structural model makes it possible to separate the preference for milk from the influence of prices, trends and information. The model also allows us to separate preferences for milkiness from preferences for fat, and thereby to obtain a more detailed picture of the preferences for milk, and thereby to answer the question of what consumers want. Some consumers want fat, while others just want milkiness, and would prefer to leave out the fat.

Over time, consumers seem to prefer milk with less fat. This change seems to be due to both a general trend but also the influence of information for *some* consumers. Most households that prefer milk with a high fat content are moderate milk consumers (i.e. prefer less than 1 litre a week). It is therefore important to take the amount of milk consumed into account when predicting the change in the total amount of fat consumed, not only the share of fat.

In order to plan, design and implement political interventions with the aim of changing consumers' preferences for fat, it is of major importance to know how different types of consumers will react to different types of interventions. Most households react to information, but the reaction is strongest among those who already prefer milk with a low fat content, while for the fat lovers, the reaction has the wrong sign, which means that information about the negative health effects of fat makes them prefer even fattier milk. Information might therefore scare low fat milk consumers out of the milk market, and still not have the desired effect on high fat milk consumers. Price policy instruments might be a more effective way of reaching high fat consumers, since most households have a negative own price elasticity for fat, while high fat consumers have the strongest reaction to prices. Households that prefer milk with a fat content lower than 0 grams per litre are price inelastic, so the price policy instrument would not influence the fat-haters to the same extent as information. All in all, prices seem to be a better policy instrument than information.

The correlation between socio-demographics and optimal share of fat, which is found in this paper, shows that a high level of fat in milk is mainly preferred by households which have a relatively low consumption of milk, or by households with children which are less than three years old and/or a relatively low income. Therefore, if prices are changed by, e.g. taxes, the effect will most likely vary between different groups of consumers.

**References:**

Andersen LM, Smed S (2008) A censored Structural Characteristics Model for Milk. In: Smed S, Empirical studies on “Health, Information and Consumer Behaviour”. PhD thesis, University of Copenhagen.

Amemiya T (1984) Tobit models: A survey. Journal of Econometrics,24: 3-61.

Bartik T (1987) The estimation of demand parameters in hedonic price models. Journal of Political Economy 95: 81-88.

Blow L, Browning M, Crawford I (2005) Revealed preference analysis of characteristics models. CAM Working paper no 4, CAM, University of Copenhagen.

Blundell RW, Duncan A (1998) Kernel regression in empirical microeconomics. Journal of Human Resources 33: 62-87.

Blundell RW, Powell JL (2003) Endogeneity in Nonparametric and Semiparametric Regression Models. In Dewatripont M, Hansen LP and Turnovsky SJ (eds.) Advances in Economics and Econometrics: Theory and Applications, Eighth World Congress, Vol. 2, Chapter 8: 312-357. Cambridge University Press, Cambridge.

Brown JN, Rosen HS (1982) On the estimation of structural hedonic price model. Econometrica 50: 765-768.

Browning M (1999) Modelling commodity demands and labour supply with m-demands. Discussion Papers 99-08, Department of Economics, University of Copenhagen, Denmark.

Danish Food Composition Databank - ed. 7.01 (2012): http://www.foodcomp.dk/v7/fcdb_download.asp (accessed February 2012).

Deaton A, Muellbauer J. (1980) Economics and consumer behaviour. Cambridge University Press, Cambridge, UK.

Diamond DB and Smith BA (1985) Simultaneity in the market for housing characteristics. Journal of Urban Economics 17: 280-292.

Ekeland I, Heckman JJ, Nesheim L. (2004). Identification and Estimation of hedonic models. Journal of Political Economy 112: 60-109.

Epple D (1987) Hedonic prices and implicit markets: Estimating demand and supply functions for differentiated products. Journal of Political Economy 95: 59-80.

Gorman, WM (1980) A Possible Procedure for Analysing Quality Differentials in the Egg Market. Review of Economic Studies 47: 843-856.

Kahn S, Lang K. (1988). Efficient Estimation of Structural Hedonic Systems. International Economic Review 29:157-166.

Ladd GW, Zober M (1977) Model of consumer reaction to product characteristics. The Journal of Consumer Research 4: 89-101.

Ladd GW, Suvannunt V (1976) A model of consumer reaction to produced characteristics. American Journal of Agricultural Economics 58: 504-510.

Lancaster K (1966) A new approach to consumer theory. Journal of Political Economy 4: 132-157.

McGuirk A, Driscoll P, Alwang J, Huang L (1995) System misspecification testing and structural change in the demand for meat. Journal of Agricultural and Resource Economics 20: 1-21.

Muellbauer J (1974) Household production theory, quality and the hedonic technique. American Economic Review 64: 977-994.

OECD (2009). 'What are equivalence scales?' Available at http://www.oecd.org/dataoecd/61/52/35411111.pdf (verified February 2012).

Pedersen AN, Fagt S, Groth VM (2010) Danskernes kostvaner 2003 – 2008 (The dietary habits of the Danes 2003 – 2008). Report from Fødevareinstituttet, DTU (In Danish)

Piggot NE, Marsh T (2004) Does food safety information impact U.S. food demand? American Journal of Agricultural Economics 86: 154-174.

Rickertsen K, Chalfant JA, Steen M (1995) The Effects of Advertising on the Demand for Vegetables. European Review of Agricultural Economics 22: 481-494.

Rosen S (1974) Hedonic prices and implicit markets: Product differentiation in pure competition. Journal of Political Economy 82: 34-55.

Schmidt TM, Kaiser HM (2004) Decomposing the variation in generic advertising response over time. American Journal of Agricultural Economic 86: 139-153.

Smed S (2005) Demand structure and willingness to pay for organic dairy products. Cahiers Options Méditerraneées 64: 33-44.

Smed S, Jensen JD (2004) Demand for low fat dairy product – demand for healthiness or taste? In: Russel CS, Krarup S (Eds.), Environment, Information and Consumer Behaviour. AKF Forlaget, Copenhagen.

Smed, S (2008) Empirical studies on "Health, Information and Consumer Behaviour". PhD thesis, University of Copenhagen.

Smith ME, van Ravenswaay EO, Thompson SR (1988) Sales loss determination in food contamination incidents: An application to milk bans in Hawaii. American Journal of Agricultural Economics 70: 513-520.

Statistics Denmark (2008). (in Danish). http://www.statistikbanken.dk/statbank5a/default.asp?w=1024

Tobin J (1958) Estimation of relationships with limited dependent variables. Econometrica 26: 24-36.

Verbeke W, Ward RW (2001) A fresh meat almost ideal demand system incorporating negative TV press and advertising impact. Agricultural Economics 25: 359-374.