DEPARTMENT OF FOOD AND RESOURCE ECONOMICS
UNIVERSITY OF COPENHAGEN

IFRO Working Paper

Does Organic Crowding Out Influence Organic Food Demand? – evidence from a Danish micro panel

Lars Gårn Hansen
Laura Mørch Andersen

2013 / 2

IFRO Working Paper 2013 / 2

Does Organic Crowding Out Influence Organic Food Demand?
– evidence from a Danish micro panel

Authors: Lars Gårn Hansen, Laura Mørch Andersen

Department of Food and Resource Economics (IFRO)

University of Copenhagen

Rolighedsvej 25

DK 1958 Frederiksberg DENMARK

www.ifro.ku.dk (www.foi.life.ku.dk)

Does Organic Crowding Out Influence Organic Food Demand?
– evidence from a Danish micro panel

Lars Gårn Hansen
Laura Mørch Andersen

IFRO
Department of Food and Resource Economics
University of Copenhagen

January 2013

Please address all correspondence to Lars Gårn Hansen, IFRO, Rolighedsvej 25, DK-1958 Frederiksberg C, Denmark. E-mail: Lgh@foi.ku.dk.

The research leading to this paper was funded by The Danish Environmental Research Programme through the Centre for Organic Farming (FØJO). We thank Søren Arnberg, Martin Browning, Ian Crawford, Søren Leth-Petersen, Mario Teisl, Gary Thompson and Mette Wier for invaluable help on concepts, estimation methodology and interpretation of results though out. Finally, we thank GfK-ConsumerTracking Scandinavia for providing access to their data.

Abstract

All Previous studies of organic food demand that investigating substitution focus on specific food submarkets and have to assume separability from other food consumption. However, consumers typically associate attributes such as e.g. healthiness and environment friendliness with organic variants of most types of food. If such general organic attributes are important for consumer behaviour then separability may not hold because the general attribute obtained from one type of organic food may be a close or even perfect substitute for the same attribute obtained from other types of organic food. In this paper we utilize a unique Danish micro panel where all food demand is registered on a disaggregated level with an organic/non-organic indicator to estimate a general food demand system with organic variants. We clearly reject the usual separability assumption and find that the behaviour of Danish consumers is consistent with them perceiving such general organic attributes. In addition estimation of a general demand system makes calculation of economy wide organic price elasticities and other insights into the structure of organic food demand possible.

Keywords: Organic consumption, crowding out, separability, AIDS model, home scan data

JEL codes: D12

1. Introduction

Organic food production is characterized by substantial restrictions on the use of pesticides and chemical fertilizer[1]. These constraints imply that organic production costs typically are higher than for comparable conventional foods. On the other hand, many consumers believe that organic food production performs better than conventional food production with regard to environmental externalities, animal welfare, and the health risks imposed on consumers and farm workers. Organic foods may also differ from conventionally produced foods with regard to traditional quality indicators such as taste, texture, appearance etc.

One would expect organic and non-organic variants of a specific type of food (milk for example) to be close substitutes, and previous estimation studies have modelled organics/non-organics as different qualities of the same food type assuming separability from other food consumption. Glaser and Thompson (1998, 2000), Thompson and Glaser (2001a and 2001b), Wier and Smed (2002) and Smed (2005)[2] all find large uncompensated own price elasticities for various organic foods (close to or below -2) and also large demand elasticities with respect to the price of conventional variants of the same food type (often close to or greater than 1). This suggests that in most food submarkets a substantial organic market share increase is to be expected if the organic price premium is reduced. If the separability assumption holds there is no reason to expect any systematic effect on the organic market shares in other food submarkets.

The separability assumption used in these studies is often necessary because of data limitations and also seems reasonable when considering attributes like flavour and texture that must be specific for each food type. On the other hand, attributes like environment friendliness and healthiness that consumers typically associate with organic variants of most or all types of food, are not necessarily perceived by consumers as specific for each food type. If consumers credit organic variants of different food types with the same general organic attributes then organic variants of different foods may become closer substitutes than the corresponding conventional foods. With such a demand pattern one would expect an organic market share increase in one food market to cause organic market shares to fall in other food markets i.e. organic crowding out.

In surveys on organic buying motives consumers typically state that attributes like environment friendliness and healthiness are important buying motives[3]. If this is so the

1 Though the specific production constraints that must be met for certification as an organic farmer vary between countries and in many cases between competing schemes within the same country (for surveys see e.g. Lampkin *et al.* (1999a and b), Sylvander and Le Floc'h-Wadel (2000), Wier and Calverley (2002)) severe constraints on chemical fertilizer and pesticide use are always implied (ifoam, 2005 and 2012).

2 The four Thompson and Glaser studies use US supermarket scanner data covering milk, frozen vegetables, and baby food assume separability as does the Wier and Smed study covering dairy products, cereals and bread, meat and "other" products using Danish self-reported consumer panel data. Smed (2005) using the same type of Danish data tests the separability structure of organic/non-organic variants of different types of milk, but assumes separability from other food types. In addition to these demand estimation studies a number of XX hedonic WTP estimates for the organic attribute have been made, see e.g. Boland and Schroeder (2002), Nimon and Beghin (1999).

3 This is seen in studies of Consumers from Denmark (Wier et al (2005 and 2008), Andersen (2008 and 2011), as well as from other countries like Sweden (Magnusson *et al.* (2003)) Holland (Hack (1995)), France (Sylvander (1993)), Germany (Frick and von Alvensleben (1997)) and the USA (Cook (1991), Huang (1996), Buzby and Skees (1994), Goldman and Clancy (1991), Byrne *et al.* (1994), Jolly (1991)). For reviews see Wier and Calverley (2002), Yiridoe *et al.* (2005), Bonti-Ankomah and Yiridoe (2006), Hughner *et al.* (2007) and Pearson et al. (2011).

crowding out effect could be substantial. The implication of this could be that although previous studies indicate that organic price premium reductions have a substantial effect on the organic market shares in most food submarkets, crowding out could cause the potential for increasing the aggregate organic food share through price premium reductions to be (much) lower.

In this paper we develop a utility model with general organic attributes and derive implications for consumer demand. We then exploit a unique Danish micro panel where food demand registered on a disaggregated level in all cases has an indicator of whether the good is organic/non-organic to test the model empirically. The household level panel data make it possible to identify household specific parameters so that we can estimate household level demand systems. Our analysis covers Danish medium to heavy organic food consumers.

The empirical evidence against the separability assumption is firm for this group of consumers. This implies that systems estimated on our data assuming separability will be biased. We find that our data is consistent with organic crowding out in this part of the Danish food market. We find relatively small aggregate organic own price elasticities on the order of -0.5 and find systematically lower food budget elasticities for organic foods than for corresponding non-organic foods.

In section 2 we develop a model of organic food demand and in section 3 tests of different utility specifications are developed. Section 4 describes our data and section 5 presents our estimation results and some implications. Section 6 concludes the paper with a brief summary of our results.

2. Modelling Organic Food Demand

Our data distinguishes between food types and organic/non-organic variants, but does not generally contain information about specific quality attributes. Further our ambition of modelling interactions covering the whole food market forces us to consider fairly aggregated food goods (e.g. dairy products, rather than whole milk, low fat milk, cream etc.). Thus our starting point is the following general utility function defined on goods at this level:

$$U = \tilde{U}(x) \tag{1}$$

where U denotes consumer utility derived from the consumption of a vector x of foods (differentiated by food type at a fairly aggregated level and by organic/non-organic variant), and $\tilde{U}(.)$ satisfies the usual regularity conditions. Though specific attributes are not observed any structure imposed on $\tilde{U}(.)$ should reflect the structure expected to be generated by underlying attributes.

First consider the classic property of weak separability that $\tilde{U}(.)$ is said to satisfy if it can be expressed as:

$$\tilde{U}(x) = U(u^1(x^1),...,u^i(x^i),...,u^n(x^n)) \tag{2}$$

where x^i are mutually exclusive vectors of foods so that $x = (x^1,...x^i,...,x^n)$ and u^i is sub-utility derived from consumption of food sub-vector x^i. Any given consumer good enters into one and only one sub-utility function u^i. The idea behind weak separability is that there are natural mutually exclusive groupings of related goods that reflect the consumer's budget decisions. Previous studies assume that organic and non-organic variants of a given food type are such natural groupings, i.e.:

$$U = U(u^1(x^{1o}, x^{1c}),...,u^i(x^{io}, x^{ic}),...,u^n(x^{no}, x^{nc})) \qquad (3)$$

where u^i is sub-utility derived from consumption of food type i and o and c in the subscript distinguish between the organic and conventional variant of each good. Intuitively the separable utility structure makes it possible to estimate sub-demand systems for each group of goods conditional only on the total budget allocated to the group[4].

When focusing on attributes such as texture, taste, appearance, freshness etc. organic and non-organic potatoes, for example, look like different qualities of essentially the same good and technically they can substitute each other in most (or all) household consumption processes. Thus when conventional quality indicators are considered the grouping of organic and non-organic variants does seem natural. Further many consumer surveys/studies suggest that conventional quality attributes are highly important when deciding whether to buy organic food variants[5]. Consumers in our dataset may, therefore, satisfy the property of weak separability as expressed in (3) and our model must allow for this possibility.

On the other hand, consumers in most surveys also associate attributes like environment friendliness and healthiness, with organic variants of most or all types of food and typically also indicate these as important buying motives (see references above). Some studies suggest that consumers in certain situations differentiate between types of healthiness contained in organic foods[6], however, these attributes are not necessarily perceived by consumers as specific for each food type. Other studies suggest that consumers' perceptions of healthiness and environment friendliness associated with organic food production are quite holistic, i.e. that consumers generally perceive these basic attributes as highly correlated/ integrated[7]. Thus to some extent consumers may be associating the same general organic attribute with organic variants of most or all food types. When only general organic attributes are considered grouping all organic variants in a separable structure may be more natural than grouping organic and non-organic variants of the same food type i.e.:

$$U = U(x^{1c},...,x^{ic},...,x^{nc}, u^o(x^{1o},...,x^{io},...,x^{no})) \qquad (4)$$

where u^o is sub-utility derived from consumption of general organic attributes.

Since the groupings implied by weak separability are mutually exclusive this

4 See Goldman and Uzawa (1964) for the original results and e.g. Pudney (1981) for a good overview of this and other separability concepts.
5 See Wier *et al.* (2008) and Andersen (2011) for studies of Danish consumers and e.g. Huang (1996), Thompson and Kidwell (1998), Loureiro and Hine (2002) for studies of US consumers.
6 Buzby and Skees (1994) and Frick and von Alvensleben (1997) find that households with children are more concerned about pesticides in foods. In the Danish context Wier and Smed (2000) find that such households consume more organic foods than other households. This could imply that consumers distinguish between healthiness contained in infant foods and foods consumed by other household members – valuing healthiness in infant foods higher.
7 See Thøgersen (1998) and Beckmann *et al.* (2001) for studies of Danish consumers suggesting this.

structure would force us to choose either a separability structure implied by conventional food attributes (3) or a structure implied by general organic attributes (4). Needless to say consumer surveys and casual observation suggest that food specific attributes are highly important to consumers so that a description that does not embody this is unrealistic. Therefore, we do not consider specification (4) to be a serious modelling alternative. The real questions here are:

- whether general organic attributes are important enough to consumers so as to make specification (3) that only embodies food specific attributes questionable and if so,
- how should organic attributes be introduced into our utility model?

What we need, for the analysis in this paper is, therefore, a utility structure that allows for both conventional and general organic attributes in an intuitive way.

In the literature two ways of imposing structure that are less restrictive than weak separability have been suggested: 1) the *latent separability* specification developed by Blundell and Robin (2000) and 2) the *characteristics* specification attributed to Gorman (1956). Both are more general specifications that emit weak separability (2) as a special case.

Latent separability

Taking outset in the weak separability specification with mutually exclusive grouping of consumed goods Blundell and Robin (2000) generalize by allowing groups to overlap. A utility function $\tilde{U}(.)$ is said to satisfy the property of latent separability if:

$$\tilde{U}(x) = \max_{\tilde{x}^1,\ldots,\tilde{x}^n} \left\{ U(u^1(\tilde{x}^1),\ldots,u^i(\tilde{x}^i),\ldots,u^n(\tilde{x}^n)) \middle| \sum_{i=1}^{n} \tilde{x}^i = x \right\} \tag{5}$$

where the sub-vectors $\tilde{x}^i$ no longer need to be mutually exclusive. In addition (5) also imposes the restriction that the allocation of x between sub-vectors $\tilde{x}^i$ maximizes utility.

First we note that if sub-vectors $\tilde{x}^i$ are mutually exclusive then weak separability results since in this case only one allocation of total consumption x between sub-utilities is possible. The advantage of the latent separability generalization can be illustrated by letting sub-utilities u^i represent e.g. the utility of different family members or the utility derived from different processes like eating breakfast and eating lunch. With such interpretations the mutually exclusive groupings of weak separability become unrealistic since several household members may consume the same good or a given good may be consumed for lunch as well as for breakfast. In contrast, latent separability allows goods to enter more than one sub-utility function. Since goods must be allocated by the household between different members or process when these are not mutually exclusive assuming that this is done so as to maximize household utility (as implied by latent separability) seems natural.

In itself relaxing the assumption of mutually exclusive definition sets is attractive in our specific context. One could in some sense combine the properties of functions (3) and (4) by designating a sub-utility function representing conventional attributes of each food type and a sub-utility function representing general organic attributes. The organic good variants could enter the sub-utility function for conventional good attributes as well as the sub-utility function for general organic attributes. However, the latent separability property implies that consumers (optimally) allocate the total amount of each organic good consumed between these two sub-utility functions. This does not fit our context. We do not think that consumers allocate organic foods either to generating conventional types of utility or to generating utility associated with e.g. environment friendliness. Rather we think of each unit of an organic good as possessing both sets of attributes in fixed proportions and so generating both types of utility when they are consumed. Though estimates of the content of general organic attributes may vary substantially across households and over time, the actual content of these attributes is presumably given by production processes beyond the control of households and therefore presumably perceived as fixed by most consumers. As we shall see below this is precisely what is implied by the characteristics specification.

Characteristics specification

In the *characteristics* model (attributed to Gorman (1956)) a given consumer good is seen as a vector of characteristics and goods are distinguished by containing characteristics in different proportions. Consumer utility (*U*) is derived from consumption of characteristics (not from consumption of goods directly) so that the consumer utility function has the following form:

$$U = U(u^1(x), u^2(x), ...u^m(x)) \tag{6}$$

where u^i is the amount of utility derived from consumption of characteristic i that is contained in the total good vector x. This resembles the latent separability specification except that here the total consumption vector enters into all sub-utilities. The consumer can not allocate goods between sub-utilities since the content of different characteristics is intrinsic to the type of good and he therefore only chooses the total amount of each good to consume. This seems more agreeable in our context.

Since we do not have data on specific attributes we must use a much aggregated specification of (6) i.e.:

$$U = U(u^1(x^{1o}, x^{1c}), ..., u^i(x^{io}, x^{ic}), ..., u^n(x^{no}, x^{nc}), u^o(x^{1o}, ..., x^{io}, ..., x^{no})) \tag{7}$$

where we have aggregated traditional quality attributes like taste or freshness for each food type into one aggregate characteristic possessed by both conventional and organic variants. We have also aggregated the general organic characteristic (e.g. healthiness, animal and environment friendliness etc.) into one general organic characteristic.

This aggregation of course substantially reduces the versatility and descriptive power for which characteristics modelling is known (see e.g. Lancaster (1966) for a classic presentation). However, we do get a generalization of the separability concept that combines (3) and (4) in an intuitive way. With this specification an organic carrot competes with non-organic carrots at supplying the aggregated conventional carrot attribute while competing with organic potatoes and milk at supplying the aggregated general organic attribute.

Often the linear characteristics specification (where u^i are linear functions) is assumed. Linearity seems intuitive when considering disaggregated characteristics (like e.g. vitamin or fat content) and disaggregated goods. Further, linearity typically implies corner solutions (i.e. only one or a few goods containing a given characteristic are consumed) which also seems reasonable from casual observation of the structure of disaggregated demand. In our context the assumption may be reasonable for the general organic characteristic since studies of Danish consumers (as noted above) suggest that these attributes are perceived in a highly aggregated way and we will use it below. However, when goods and conventional characteristics are aggregated as we must do here linearity seems restrictive and we will not impose this assumption on the food type sub-utility functions.

Price elasticity implications of the characteristics specification

In this subsection we derive some elasticity implications of the general attribute specification (7). We contrast with the food type separability specification (3) which is obtained from (7) directly when $dU/du^o=0$, i.e. when the utility derived from the general organic attributes is zero. In doing so we keep our perspective in mind, i.e. if there is a general organic demand effect we do not expect it to dominate food type attributes.

Consider the consumers' problem of maximizing utility under a budget constraint with the general attribute specification (7).

$$\begin{aligned} &\underset{x^{1o},x^{1c},\ldots,x^{no},x^{nc}}{Max} U = U(u^1(x^{1o},x^{1c}),\ldots,u^n(x^{no},x^{nc}),u^o(x^{1o},\ldots\ldots,x^{no})) \\ &s.t. \qquad px \le y \end{aligned} \tag{8}$$

where y is expenditure. This yields the following set of first order conditions:

$$\lambda \begin{pmatrix} p^{1o} \\ p^{1c} \\ \vdots \\ p^{no} \\ p^{nc} \end{pmatrix} = \begin{pmatrix} (\delta U/\delta u^1)(\delta u^1/\delta x^{1o}) + (\delta U/\delta u^o)(\delta u^o/\delta x^{1o}) \\ (\delta U/\delta u^1)(\delta u^1/\delta x^{1c}) \\ \vdots \\ (\delta U/\delta u^n)(\delta u^n/\delta x^{no}) + (\delta U/\delta u^o)(\delta u^o/\delta x^{no}) \\ (\delta U/\delta u^n)(\delta u^n/\delta x^{nc}) \end{pmatrix} \tag{9}$$

where λ is the LaGrange multiplier to the budget constraint (i.e. the marginal utility value of income). Rescaling the unit of measurement of each good so that $\delta u^o/\delta x^{io}=1$ for all i, the first order conditions for the representative food type i can be written more compactly as:

$$\lambda^i \begin{pmatrix} p^{io} - \lambda^o \\ p^{ic} \end{pmatrix} = \begin{pmatrix} \delta u^i/\delta x^{io} \\ \delta u^i/\delta x^{ic} \end{pmatrix} \tag{10}$$

where $\lambda^i = \lambda/(\delta U/\delta u^i)$ is the marginal utility value of income expressed in food type i utility equivalents and $\lambda^o = (\delta U/\delta u^o)/\lambda$ is utility value of the general organic attribute expressed in monetary equivalents. Equation (10) expresses the set of first order conditions for food type i in terms of the food type attribute while deducting from the price the utility value (measured in monetary units) of the organic good.

Now consider the marginal effect on food type *i* demand of a price change of variant *k* (where *k* can take the value *o* or *c*) of another food type *j.* The effect on equilibrium is found by differentiating (10) i.e.:

$$\frac{\delta\lambda^i}{\delta p^{jk}}\begin{pmatrix} p^{io}-\lambda^o \\ p^{ic} \end{pmatrix}+\lambda^i\begin{pmatrix} \Delta_{jk}^{io}-\dfrac{\delta\lambda^o}{\delta p^{jk}} \\ \Delta_{jk}^{ic} \end{pmatrix}=A\begin{pmatrix} \dfrac{\delta x^{io}}{\delta p^{jk}} \\ \dfrac{\delta x^{ic}}{\delta p^{jk}} \end{pmatrix}$$

where Δ_{jk}^{ir} is Kronecker's delta (taking the value 1 when *jk=ir* and 0 otherwise) and

$$A=\begin{pmatrix} \delta^2u^i/\delta x^{io}\delta x^{io} & \delta^2u^i/\delta x^{io}\delta x^{ic} \\ \delta^2u^i/\delta x^{io}\delta x^{ic} & \delta^2u^i/\delta x^{ic}\delta x^{ic} \end{pmatrix}.$$

Solving for demand effects we have:

$$\begin{pmatrix} \dfrac{\delta x^{io}}{\delta p^{jk}} \\ \dfrac{\delta x^{ic}}{\delta p^{jk}} \end{pmatrix}=A^{-1}\begin{pmatrix} \lambda^i\Delta_{jk}^{io}+\dfrac{\delta\lambda^i}{\delta p^{jk}}(p^{io}-\lambda^o)-\lambda^i\dfrac{\delta\lambda^o}{\delta p^{jk}} \\ \lambda^i\Delta_{jk}^{ic}+\dfrac{\delta\lambda^i}{\delta p^{jk}}p^{ic} \end{pmatrix} \tag{11}$$

Since *A* is symmetric so is A^{-1} and defining $A^{-1}=\begin{pmatrix} a_1 & a_3 \\ a_3 & a_2 \end{pmatrix}$ we can write (11) as:

$$\begin{pmatrix} \dfrac{\delta x^{io}}{\delta p^{jk}} \\ \dfrac{\delta x^{ic}}{\delta p^{jk}} \end{pmatrix}=\lambda^i\begin{pmatrix} a_1\Delta_{jk}^{io}+a_3\Delta_{jk}^{ic} \\ a_3\Delta_{jk}^{io}+a_2\Delta_{jk}^{ic} \end{pmatrix}+\frac{\delta\lambda^i}{\delta p^{jk}}\begin{pmatrix} [a_1(p^{io}-\lambda^o)+a_3p^{ic}] \\ [a_3(p^{io}-\lambda^o)+a_2p^{ic}] \end{pmatrix}-\lambda^i\begin{pmatrix} a_1\dfrac{\delta\lambda^o}{\delta p^{jk}} \\ a_3\dfrac{\delta\lambda^o}{\delta p^{jk}} \end{pmatrix} \tag{12}$$

As initially noted in this subsection if $dU/du^o=0$ then weak separability in food types results. When we correspondingly set $\lambda^o=0$ ($\delta U/\delta u^o=0 \Rightarrow \lambda^o=(\delta U/\delta u^o)/\lambda=0$) and therefore $\delta\lambda^o/\delta p^{jk}=0$ in (12) the last element of the right hand side becomes zero and when p^{jk} is outside the separable group (i.e. $i\neq j$ so that Δ=0) then (12) reduces to:

$$\begin{pmatrix} \dfrac{\delta x^{io}}{\delta p^{jk}} \\ \dfrac{\delta x^{ic}}{\delta p^{jk}} \end{pmatrix} = \frac{\delta \lambda^{i}}{\delta p^{jk}} \begin{pmatrix} [a_1 p^{io} + a_3 p^{ic}] \\ [a_3 p^{io} + a_2 p^{ic}] \end{pmatrix} \tag{13}$$

This is the classic first order conditions for weak separability (see e.g. Goldman and Uzawa (1964), Deaton and Muellbauer (1980) or Pudney (1981)). In (13) the elements of the right hand side vector are the marginal effect on consumption of a change in the budget allotted to food type *i* (which for normal goods will be positive). A change in the price of a good outside the separable group only affects demand of goods within the group through the budget effect ($\delta\lambda^{i} / \delta p^{jk}$). Depending on which outside price is being changed the budget effect may vary in sign (positive if the separable group substitutes or negative if it complements the good in question) and size, but the ratio between the two price effects in (13) will be the same for all prices p^{jk} outside the weakly separable group because the budget effect cancels out (the classical weak separability result).

We now evaluate (12) to determine how the introduction of general attributes changes the structure of cross-price effects with other food types (i.e. $\Delta_{jk}^{ir}=0$). In addition to the ratio preserving budget effect in (13) we also have an effect from the general organic attribute (last element in (12)) that may cause ratios to deviate between different p^{jk}. From standard assumptions we know that $a_1<0$, $a_2<0$, $a_3>0$, $\lambda^{i}>0$ and $\lambda^{o}>0$. Further, an increase in the price of an organic good *j* must cause the shadow price of the organic attribute to rise (i.e. $\delta\lambda^{o} / \delta p^{jo}>0$). Finally, we generally expect an increase in the price of a non-organic good *j* to cause the shadow price of the organic attribute to fall (i.e. $\delta\lambda^{o} / \delta p^{jo}<0$) since a main effect will be to shift consumption toward the organic variant of food type *j*.[8] We therefore generally expect the following to hold:

$$\begin{aligned} &-a_1(\delta\lambda^{o} / \delta p^{jo})>0 \text{ and} \\ &-a_1(\delta\lambda^{o} / \delta p^{jc})<0 \text{ and} \\ &-a_3(\delta\lambda^{o} / \delta p^{jo})<0 \text{ and} \\ &-a_3(\delta\lambda^{o} / \delta p^{jc})>0 \end{aligned} \tag{14}$$

Now consider cross-price elasticities between organic and non-organic variants of the same food type. Using (13), inserting for Kronecker's delta and rearranging we have:

8 A positive sign could result if organic and non-organic variants of food type *j* are poor substitutes in the food type *j* attribute and if the *j* attribute at the same time complements e.g. food attribute *k* with a large organic variant market share. In this case the fall in attribute *j* consumption could cause a net fall in organic attribute consumption. However, this is unlikely since by assumption organic and non-organic variants are close substitutes in the food type attribute.

$$\frac{\delta x^{ic}}{\delta p^{io}} = \frac{\delta \lambda^{i}}{\delta p^{io}}[a_3(p^{io} - \lambda^{o}) + a_2 p^{ic}] + \lambda^{i} a_3 (1 - \frac{\delta \lambda^{o}}{\delta p^{io}})$$

As long as x^{ic} is a normal good in production of food type i utility (see above) we know that

$$[a_3(p^{io} - \lambda^{0}) + a_2 p^{ic}] > 0$$

so that the first element on the right-hand side of the equation is positive. Noting that $\lambda^{o} = (\delta U / \delta u^{o}) / \lambda$ is the utility value of the general organic attribute expressed in monetary equivalents by definition we have that $\delta \lambda^{o} / \delta p^{io} \leq 1$ and thus that the second element is non-negative[9]. Thus by Slutsky symmetry we have:

$$\frac{\delta x^{ic}}{\delta p^{io}} > 0, \frac{\delta x^{io}}{\delta p^{ic}} > 0 \qquad (15)$$

3. Testing Utility Specifications

Consumer surveys and casual observation suggest that food-specific attributes are highly important to consumers and a description that does not embody this seems unrealistic. We therefore do not seriously consider specification (4), where general organic attributes dominate consumer choice to such a degree that organic goods can be modelled as a separable group. The real questions here are whether food-specific attributes are so important to consumers so as to make specification (3) embodying the intuitively reasonable assumption of weak separability of the food types applicable and if not whether our data is consistent with the demand structure implied by the general attribute specification (7).

Testing the weak separability specification

In this paper we use the AIDS estimation framework (see Deaton and Muellbauer (1980)). As is the case for a wide class of flexible functional forms (see Blackorby *et al.* (1977) this specification is separability inflexible. This means that an AIDS system is globally inconsistent with (cannot result from) a utility function with a separable subgroup of consumer goods[10]. Since the AIDS specification is a flexible local approximation of the demand system one can resort to testing separability locally (i.e. for a given data point such as the data mean) as done by e.g. Moschini *et al.* (1994). However, the interpretation of local separability tests in a system that is globally inconsistent with separability is not clear and this approach has been criticized (see e.g. Aizcorbe (1992)). Instead we use an alternative approach developed by Browning and Meghir (1991). The idea behind this approach is that

9 In fact since there are many organic goods that are close substitutes in the organic attribute we expect $\delta \lambda^{o} / \delta p^{jk}$ to be substantially lower than 1.

10 Global separability of an AIDS system can only be ensured if one also makes the highly restrictive assumptions of homotheticity for the separable group and that all income elasticities in this group are 1 (see Moschini *et al.* (1994)).

optimal demands for a subset of goods (given by the vector x^+) conditional on the demand for all other goods (given by the vector x^-) can be found as the x^+ vector that minimizes cost (p^+x^+) of achieving a given utility level $\bar{U}$.

Following Browning and Meghir we consider the conditional cost function:

$$C(p^+, x^-, \bar{U}) = \min_{x^+}(p^+x^+ \,|\, U(x^+, x^-) = \bar{U}) \tag{16}$$

. Note that although we consider a conditional system no structure has been imposed on the underlying utility function $U(.)$.

The AIDS specification for this system is:

$$\ln C(p^+, x^-, \bar{U}) = \ln a(p^+, x^-) + \bar{U}b(p^+, x^-)$$

where

$$\ln a(p^+, x^-) = \sum_i \alpha_i(x^-) \ln p^i + ½ \sum_i \sum_j \gamma_{ij} \ln p^i \ln p^j \tag{17}$$

and

$$\ln b(p^+, x^-) = \sum_i \beta_i(x^-) \ln p^i$$

which gives the following system of derived budget share equations:

$$w^i = \alpha_i(x^-) + \sum_j \gamma_{ij} \ln p^i + \beta_i(x^-) \ln(y / a(p^+, x^-)) \tag{18}$$

where $y = p^+x^+$ is expenditure on the subset of goods in question (see Deaton and Muellbauer (1980) for derivation details). Note that the parameters $\alpha_i(x^-)$ and $\beta_i(x^-)$ of the AIDS system are specified as functions of the conditioning variables x^- whereas we (like Browning and Meghir) assume that the γ_{ij} parameters are independent of the conditioning variables. After assuming a functional form for $\alpha_i(.)$ and $\beta_i(.)$ this system can be estimated using data on prices p^+, quantities of conditioning variables x^- and expenditures y.

Browning and Meghir show that if the group of goods in question is a separable group (i.e. if $U(x^+, x^-) = U(u(x^+), x^-)$ then the cost function can be expressed as $C(p^+, h(x^-, \bar{U}))$ i.e. we have that:

$$C(p^+, h(x^-, \bar{U})) = \min_{x^+}(p^+x^+ \,|\, U(u(x^+), x^-) = \bar{U}) \tag{19}$$

In the corresponding AIDS specification $h(x^-, \bar{U})$ takes the place of $\bar{U}$ in (13) and parameters

α_i and β_i no longer depend on the conditioning variables (i.e. under separability the effect of these only works through the budget y).

This allows us to test the separability specification against a fairly general specification of the unconstrained utility function. We simply test whether the set of coefficients to conditioning variables for the chosen specification of $\alpha_i(x^-)$ and $\beta_i(x^-)$ in the estimated system (18) can be set to zero. Though the non-separable version of (18) imposes a number of restriction (e.g. that the γ_{ij} parameters are independent of the conditioning variables) this test for separability is more general and its interpretation clearer than local separability tests.

Testing the general attribute specification

It turns out that we reject separability for all food type groups in our data and therefore turn to testing the less restrictive general attribute specification (7). Ideally we would like to test this structure against a general specification of the unconstrained utility function. However, for this no existing procedure seems obvious.

One possibility that we have considered is to extend the Browning/Meghir approach. Taking outset in (10) one could define the corrected organic price $\tilde{p}^{io} = p^{io} - \lambda^o$. Using this price instead of p^{io} in (18) separability would result if the general attribute specification (7) is the underlying utility structure (i.e. if the general attribute specification applies we should be able to test the set of coefficients to conditioning variables in $\alpha_i(x^-)$ and $\beta_i(x^-)$ to zero). The problem with this approach is practical. λ^o is an unknown function of the conditioning variables x^- and x^+ that must be specified and estimated. Disentangling $\lambda^{io}(x^+, x^-)$ from $\alpha_i(x^-)$ and $\beta_i(x^-)$ when estimating (18) would demand a lot from our data (or restrictive functional assumptions).

Instead we take another approach. Given that separability is rejected we estimate a general demand system and then check if the resulting price effects correspond to the effects we would expect with general organic attributes.

Barring inferiority we found that organic and non-organic variants will continue to be substitutes under the general organic attribute specification (condition (15) above). This condition (positive within food type cross-price elasticities) is easy to check after estimation of a general demand system.

We can also derive conditions on cross-price elasticities with other food types. Consider the two ratios of compensated cross-price elasticities $\frac{s_{jo}^{io}}{s_{jo}^{ic}}$ (the demand elasticity of the organic over the non-organic variant of food i both with respect to the organic variant of food j) and $\frac{s_{jc}^{io}}{s_{jc}^{ic}}$ (the demand elasticity of the organic over the non-organic variant of food i both with respect to the non-organic variant of food j). The ratio of these ratios (R) is:

$$R = \frac{s_{jo}^{io}}{s_{jo}^{ic}} \bigg/ \frac{s_{jc}^{io}}{s_{jc}^{ic}} = \frac{\delta x^{io} / \delta p^{jo} (p^{jo} / x^{io})}{\delta x^{ic} / \delta p^{jo} (p^{jo} / x^{ic})} \bigg/ \frac{\delta x^{io} / \delta p^{jc} (p^{jc} / x^{io})}{\delta x^{ic} / \delta p^{jc} (p^{jc} / x^{ic})} = \frac{\delta x^{io} / \delta p^{jo}}{\delta x^{ic} / \delta p^{jo}} \bigg/ \frac{\delta x^{io} / \delta p^{jc}}{\delta x^{ic} / \delta p^{jc}} \quad (20)$$

Inserting (12) after regrouping we have:

$$R = \frac{s_{jo}^{io}}{s_{jo}^{ic}} \bigg/ \frac{s_{jc}^{io}}{s_{jc}^{ic}} = \frac{\left[\frac{(\delta\lambda^{i} / \delta p^{jo})[a_1(p^{io} - \lambda^{o}) + a_3 p^{ic}] - a_1(\delta\lambda^{o} / \delta p^{jo})}{(\delta\lambda^{i} / \delta p^{jo})[a_3(p^{io} - \lambda^{o}) + a_2 p^{ic}] - a_3(\delta\lambda^{o} / \delta p^{jo})} \right]}{\left[\frac{(\delta\lambda^{i} / \delta p^{jc})[a_1(p^{io} - \lambda^{o}) + a_3 p^{ic}] - a_1(\delta\lambda^{o} / \delta p^{jc})}{(\delta\lambda^{i} / \delta p^{jc})[a_3(p^{io} - \lambda^{o}) + a_2 p^{ic}] - a_3(\delta\lambda^{o} / \delta p^{jc})} \right]} \quad (21)$$

When only considering the weakly separable food type attributes ($\delta\lambda^{io} / \delta p^{jk} = 0$) we see that R=1 (the classical separability result) and that only the last element of each of the four differences in (21) can cause a deviation from 1. We can therefore use (14) to evaluate how the introduction of general organic effects changes R. The top element of the top ratio increases while the bottom element decreases so that the top ratio increases (i.e. organic variants become relatively closer substitutes). In the bottom ratio the top element decreases while the bottom element increases so that the bottom ration decreases. Thus, if the first element of each of the four differences is positive (and the introduction of the second element does not cause the sign to change) we expect to observe R>1.

The intuition here is that where we under weak separability have constant within group price effect ratios general organic attributes cause organic variants to become relatively closer substitutes. The specifics of how general organic attributes affect R vary depending on whether food type attributes are complements or substitutes and on whether general organic effects are so large that they cause the sign of the cross-price effect to change. However, for each set of observed signs in the price effects used to calculate R we can deduce whether the sign combination could be generated by a general organic attribute utility specification and if so which constraints R must satisfy. This is done in detail in appendix 1.

These checks constitute a real test since substantial restrictions on resulting cross-price elasticities must be satisfied, but it is not a strict test of general organic attributes in the same way the Browning/Meghir approach tests separability. Since other utility function structures might also generate price effects that pass these tests this only indicates that our data is consistent with the general attribute utility specification – it does not rule out other structures. On the other hand, one of the general attribute implications that we test for (the presence of organic crowding) may have independent interest since some policy implications follow directly from organic crowding out irrespective of the underlying utility specification.

4. Data

The data used in this study is from self-reported consumer diaries collected by GfK ConsumerTracking Scandinavia (see www.gfk.dk) as part of their consumer panel. GfK uses the panel data to do market analyses for its customers (e.g. evaluation of TV-ad. campaigns etc.).

At any one time during the data period (1997-2000) the consumer panel consisted of about 2000 Danish households. About 20% of the panel are replaced each year. When recruiting it is attempted to ensure representativeness with regard to regional distribution, household size and type, age etc. Panel participants are not paid, but awarded small prizes each year.

In each family a diary keeper is appointed (typically the person responsible for most of the shopping). Each week the diary keeper fills in a detailed pre-printed diary form with information about all types of food, groceries and some other ‘non-durable’ daily goods purchased by family members and sends the report to GfK[11]. The average report rate is about 80% with rates dropping to about 70% during summer and Christmas vacations. In our version of the panel the average number of weeks covered is 95 per household.

For each purchased good reported in the week diary trip the following information is recorded:

- Scanner data (EAN-code i.e. bar code or “stregkode”, see www.ean.dk for more information). Our data contain a number of more aggregated good group codes derived from the EAN-codes one of which is very close to the EAN-code.
- Number of units purchased.
- Price per unit.
- Whether the good was on sale or not.
- Organic/conventional indicator (this is recorded for all goods that can possibly be organic).
- Other good characteristics (these vary in number and type between goods, e.g. for milk indicators for fat content and type (chocolate milk, buttermilk etc.) are reported, for some goods no characteristics are reported).

In addition the following information is recorded for each shopping trip:

- Name/type of store (e.g. Kvickly, SuperBrugsen, Bilka, Irma …).
- The day of the week and time of day of the shopping trip.
- Who participated in the shopping trip.
- The total value of the goods purchased on the shopping trip.

Finally, households annually supply information on:

- socio-demographics,
- education,
- income category,
- club membership and media use etc.

The GfK data has previously been used to study the effect of the Swan label indicating environmentally friendly production (Bjørner et al. 2004), differences in dietary health (Smed, 2008; Smed and Jensen, 2004) and consumption of organic foods (Andersen, 2011; Andersen, 2008; Wier et al., 2005; Wier et al., 2008). For further documentation of the GfK ConsumerTracking Scandinavia data see Andersen (2006) and Smed (2008).

Andersen (2006) also provides an extensive analysis of the panel’s representativeness concluding that the panel is quite representative in the investigated socio-demographic dimensions (although the fact that participating households are willing to undertake the extensive work of filling out diaries with only token compensation suggests that they in some respects must be unrepresentative of the general population). Further, the long participation time for panel

11 Daily goods not covered include snacks (gum, chocolate etc.) consumed outside the home, consumption in canteens or at the work place or in the hospital, daycare institutions etc.

households and the fact that GfK systematically consistency checks registered EAN-codes and attributes (including the organic/non-organic code) suggests that the data quality is high.

In our context two data characteristics are especially important. First of all, the complete categorization of organic/non-organic food variants is of course essential for our study. Second, the fact that each household is observed many times over the data period makes it possible to identify household specific parameters, when estimating a demand system and thereby take account of otherwise unobserved heterogeneity between households.

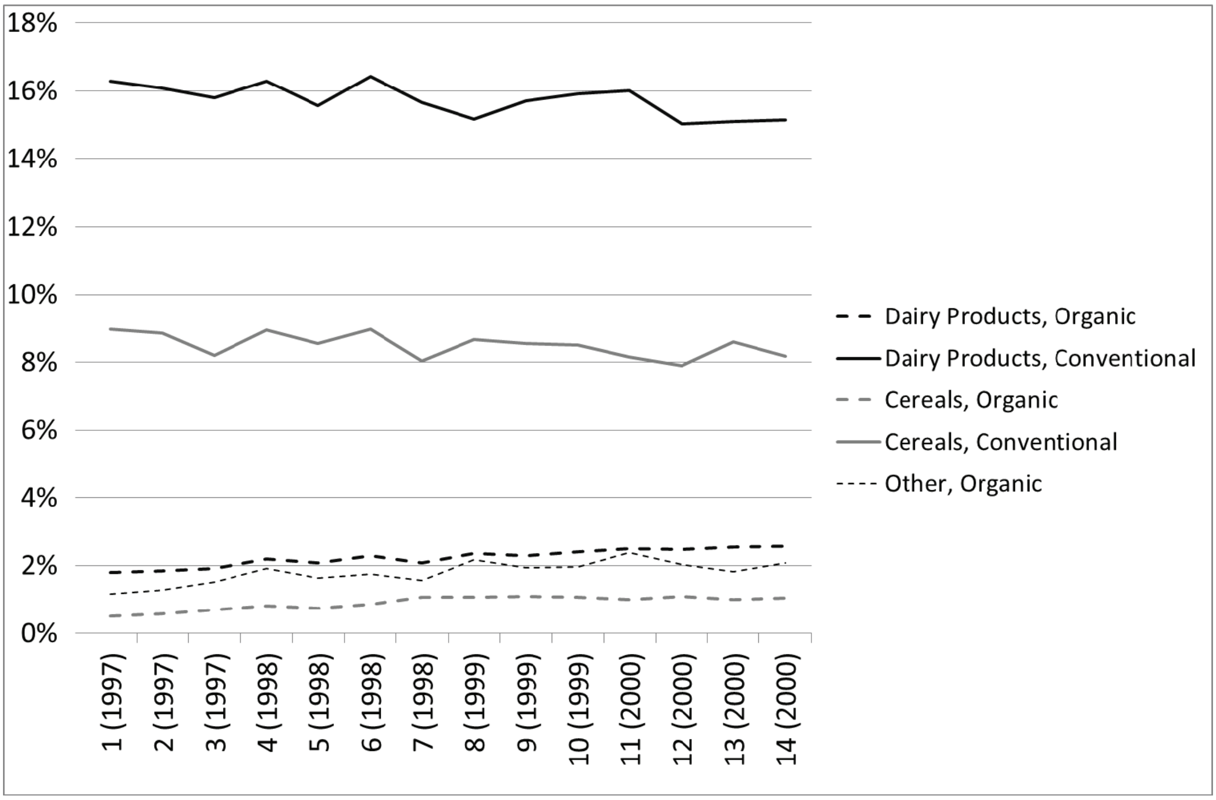
Since we need to cover all organic food consumption we must use fairly aggregated food goods for estimation. For the study in this paper data are aggregated into the three different commodities Dairy products (milk, butter, cheese etc.), Organic and conventional Cereals (oats, cornflakes, bread etc.) and split each of these into organic and conventional food. This leads to six different aggregated foods (see appendix 2 for a detailed specification of each category). Further, in order to reduce the importance of dynamics caused by storable foods we also aggregate over time into 14-week-periods.

Aggregate group/time period prices are constructed for each household for each of the six food groups as Fisher price indexes using household specific quantity weights and common base prices. The basic observations being aggregated over are close to the EAN-bar code level which is a very detailed grouping (e.g. organic whole milk in a 1 litre carton of a specific brand sold in a specific store chain in a specific week). At this level common prices are calculated as registered aggregate expenditures in all consumer diaries divided by the aggregate number of units purchased as registered in the consumer diaries. Household specific quantity weights are the registered quantities in the specific households' diary. After aggregation quantity index of aggregate goods are calculated as aggregate expenditure divided by the aggregate price index.

The aggregated GfK-dataset[12] covers 14 time periods of 14 weeks' duration each spanning from April 1997 to December 2000. The data contains 26,114 observations from 2,947 households. The data set is summarized in figures 1 and 2. In figure 1 we present budget shares out of total food expenditure of five of the six aggregated food categories used in the following estimations.

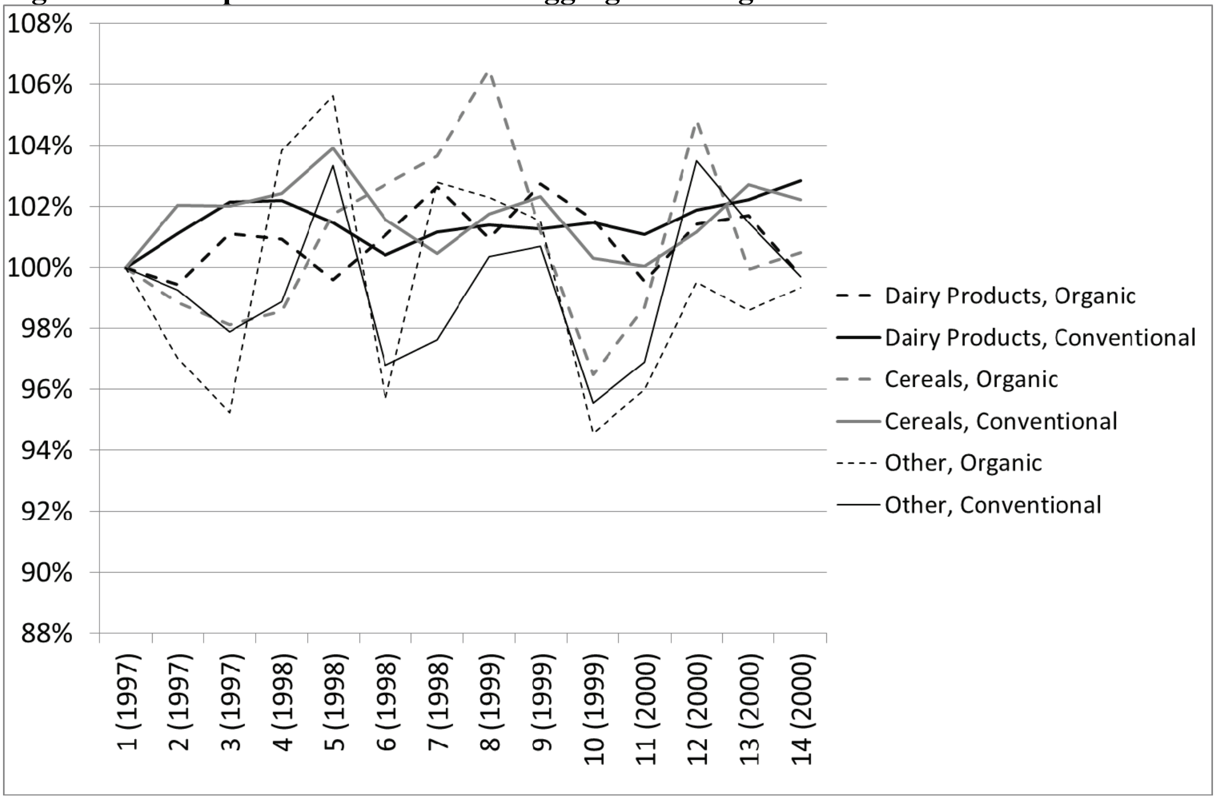
Figure 1: Mean food expenditure shares

12 In addition to the specified aggregation we have also deleted observations of food purchased from gas stations, kiosks etc. Because of the fairly strict Danish opening hours regulations for normal stores we believe that these purchases are often the result of "unusual"/non-optimizing behaviour like forgetting to purchases something before normal closing hours. Though these purchases only account for a small part of the total food consumption they are characterized by much higher prices and a highly limited range of products to choose from. Modelling results do not differ substantially, but significance of estimations is reduced somewhat if these purchases are included. Finally the about 10% of households that did not consume organic foods during the data period were drooped from the dataset.



Note: Budget share for non-organic other goods is omitted. It is substantially larger than other shares (about 70%) causing scaling problems and can be calculated as one minus the sum of the presented shares.

Figure 2: Mean price index for the six aggregate food goods



As we see mean shares and prices do not vary much over the data period. However, share and price variation over time are substantially larger for the typical household so that there is ample variation to estimate the household level equations that is our goal.

Finally, it is important to note that the various estimations presented in the following use different subsets of the aggregated dataset that is summarized in figures one and two. In the next section we present an integrated discussion of the chosen model setup, data aggregation and the final data selection in connection with each estimation.

5. Estimation and Results

When developing an estimation setup for household level week by week purchase accounts a number of issues must be addressed:

1. We do not have complete data on non-food purchases.
2. Seasonal demand variation and trends.
3. Advertising, information campaigns and other media information on organic foods etc.
4. The use of price/quantity index when estimations are based on aggregate goods may introduce spurious dependence (so called division bias).
5. Since households only report about 80% of the weeks they participate there are many "holes" in the week-to-week time series for each family.
6. Storable foods may cause substantial week-to-week dynamics.
7. Data contain a large number of zero purchase observations (i.e. observations where consumers report no purchases within one or more of the six food groups).

Issue 1) Because of the incomplete coverage of non-food consumption in data we only model food consumption and have to assume that food consumption is seperable from other consumption.

Issues 2 and 3) Since we do not have comprehensive data on advertising, information campaigns, and other media information we introduce dummy variables for each time period. These capture variation over time affecting all households and so are hopefully able to control for most of the effect of these missing variables as well as capturing seasonal variation etc.

Issue 4) Since our ambition to cover all organic consumption forces us to consider aggregated commodity groups we must ensure that the procedure we use to construct the aggregate variables does not introduce spurious dependence between the left hand side aggregate and the right hand side aggregates. This would for example be the case if we let a quantity index be a function of a price index in our estimations while calculating the quantity index as total expenditure divided by the price index (so called division bias). Here, however, we estimate an AIDS system where the left hand side variables are expenditure shares that are independent of how the right hand side price (and quantity) indexes are constructed and so we do not introduce dependence through aggregation.

Issues 5 and 6) The many "holes" in the time series for each family (caused by missing diaries and by eliminating observations with corner solutions) make modelling of the week to week dynamics caused by storable foods problematic. Since our model is quite complex with out trying to model storage dynamics we have addressed this problem by aggregating over time (while scaling aggregates so as to adjust for missing weeks). Here we aggregate into 14-week-periods, which is long enough that we expect the dynamics of storage to be reduced substantially for many foods while still giving a reasonable number of observations (between six and seven on average) per household.

Issues 7) Even after aggregation we find a large number of zero consumption observations in the data (especially for organic variants reflecting that for many households only a small part of food consumption is organic). When a data observation contains a zero consumption observation the corresponding non-negativity constraint is binding in the consumer optimization that generated the data observation. This then gives rise to estimation difficulties because for any given utility function the parameters of the derived demand system will differ depending on which (if any) non-negativity constraints are binding. Thus data generated with out any binding non-negativity constraints will be described by one set of demand system parameters while data generated when a certain set of non-negativity constraints are binding will be described by another set of demand system parameters.

Lee and Pitt (1986 and 1987) have developed an estimation procedure where data with and with out corner solutions can be included in the same estimation. The idea of the procedure is to use the demand system derived without binding non-negativity constraints on data with corner solutions while replacing the actual price of the zero consumption good with its shadow price (i.e. the price that without non-negativity constraints would result in zero consumption). The actual price of the unconsumed good must be an upper bound on the shadow price and the Lee and Pitt procedure utilises this constraint in the estimation. Pool observations in this way increases efficiency but the Lee and Pitt procedure requires that prices of zero consumption goods that in our data are unobserved can be constructed. However, there is no obvious way of doing this in our case since the missing prices are household specific aggregate index whose composition we cannot know. Constructing price index through some rough procedure would make these highly uncertain and perhaps biased indicators of the unobserved prices so that pooling data in this way make estimation results less reliable in our case.

Instead we choose to address estimation by simply restricting the dataset to observations of internal solutions where no consumption categories are zero (see e.g. Weaver and Lass (1989) for a nice presentation of the problem and this solution). Doing this ensures that all data used in the estimation are generated from the same demand system and if there are enough observations efficiency will not be an important issue. However, restricting the dataset in this way also means that estimation must take this selection process into account so as to avoid generating selection bias.

Consider a consumer deciding what to buy at given prices. Initially he solves his problem with out applying any non-negativity constraints. After solving this problem he implements the solution if all non-negativity constraints are satisfied. If some are not, he solves the constrained optimisation problem conditional on these zero purchases. By only estimating with data satisfying the non-negativity constraints we truncate the data distribution generated by the initial optimisation at zero (i.e. in effect dropping the unobserved data points with negative damand elements) and so we must take account of this when estimating.

Weaver and Lass (1989) use the popular Heckman two step procedure where inverted Mils ratios (found in an initial Probit estimation) are included when estimating the demand system on the truncated dataset so as to avoid selection bias. This is a general approach to the selection problem where the set of variables and parameters affecting the selection process may differ from the set of variables and parameters relevant for demand estimation. However, here selection and demand are the result of solving the same consumer optimisation problem (i.e. observations are deleted when the unconstrained demand system results in negative demand elements). We therefore use a specific version of the Heckman set up where the selection and demand equations are the same (corresponding to the Tobit estimation set up). By including the corresponding inverted Mills ratios in the estimation we correct for the selection bias caused by restricting the dataset to internal solutions.

All though restricting data for a given household to internal solutions does not bias estimates when the estimation takes account of the truncation if all household observations are deleted the household falls out of the estimation altogether. Since households with small organic budget shares have a higher probability of zero consumption observations more observations from these households are deleted. This may in turn cause a higher proportion of low organic share households to fall out of the dataset thereby making the sample on which we estimate less representative of the population of Danish organic food consumers. In connection with each estimation below we give an indication of the scale of this problem which must be kept in mind when interpreting results.

Testing for weak separability

We use the Browning/Meghir procedure to test for separability of each of the three food type groups (dairy products, cereals, and other products). The AIDS system for the given food type i and variant k for household h group consists of two budget share equations: one for the organic variant (k=o) and one for the non-organic variant (k=c) of the following form (see equation (18)):

$$w^{ikh} = \eta_{ikh} + \sum_{t} \omega_{ikt} D^{t} + \alpha_{ik}(x^{-h}) + \sum_{r=o,c} \gamma_{ikir} \ln p^{irh} + \beta_{i}(x^{-h}) \ln(y^{h} / a(p^{+h}, x^{-h})) \qquad (22)$$

where η_{ikh} is the household specific fixed effect for budget share *ik,* D^{t} are time period dummies and ω_{ikt} the corresponding parameters for budget share *ik*. Following (17) the log price index becomes:

$$\ln a(p^{+h}, x^{-h}) = \sum_{ik} (\eta_{ikh} + \sum_{t} \omega_{ikt} D^{t} + \alpha_{ik}(x^{-h})) \ln p^{ikh} + \sum_{k=o.c} \sum_{r=o,c} \gamma_{ikir} \ln p^{ikh} \ln p^{irh} \qquad (23)$$

We define the following functions of the conditioning variables:

$$\alpha_{i}(x^{-}) = \sum_{j \neq i} \tilde{\alpha}_{j} \frac{x^{jo}}{x^{jc}} \text{ and } \beta_{i}(x^{-}) = \beta_{i} + \sum_{j \neq i} \tilde{\beta}_{j} \frac{x^{jo}}{x^{jc}} \qquad (24)$$

so that estimation is conditioned on the ratio of organic to non-organic quantities for all other food types than the one for which the equation is estimated. Adding up, homogeneity and symmetry are assumed and estimation is done by mean correcting all variables with household means so as to sweep out fixed effects (these are then calculated after estimation). Technically we estimate the AIDS system by iterating. In the first iteration we use the Stone index to approximate the price index $a(p^{+}, x^{-})$ which is then calculated using estimated parameters in the following iterations until the relative parameter change when re-estimating is lower than 0.001%.

When estimating we assume that prices are exogenous while the budget *y* and the conditioning variables may be endogenous. These are all instrumented initially where we use total expenditures on daily goods for the household (assumed to be exogenous) as an instrument for the food type budget *y* and non-organic prices as instruments for the conditioning quantity ratios.[13] The system is estimated with SAS: Proc Model using the GMM method after one of the two equations was eliminated to avoid simultaneity: All estimated models are highly significant with expected compensated signs of predicted budget

---

13 An advantage of the Browning/Meghir approach is that zero consumption in conditioning variables is unproblematic thus we only need to delete observations with zero consumption in the modelled subsystem. However, since no price observations are available for zero consumption observations we are left with no obvious instrument for organic conditioning quantities if $\alpha_{i}(x^{-})$ were a linear function of all quantities (remembering that zero consumption is found almost exclusively among organic quantities). This is why we have chosen to condition on the ratio of organic to non-organic quantities using the non-organic price as an instrument. All instruments are highly significant when regressed on the variable for which it is thought to be an instrument. Correlation of the set of instruments with potentially endogenous variables is typically between 0.05 and 0.15. Finally, to ensure consistency when calculating $a(p^{+}, x^{-})$ we use the predicted values from the regression of instrumented variables on all exogenous variables instead of the original variable values of instrumented variables.

shares for almost all observations, for own and cross-price elasticities in all cases for over 70% of the observations and typically for 85-95% of the observations, and for budget elasticities typically for over 90% of the observations (see appendix 3).

In table 1 we present for each of the three food types Sargan test of exogeneity of surplus instruments for the estimation with all the potentially endogenous variables instrumented and for the estimation where conditioning variables are not instrumented (but the budget is instrumented) as well as the Hausman test of exogeneity of conditioning variables.

Table 1: Test of exogeneity of instruments and conditioning variables

	Test statistic	(P-value)
Dairy products:		
Sargan test of Exogeneity of instruments, Conditioning variables instrumented	$\chi^2(4)=$ 7.443	(0.1142)
Sargan test of Exogeneity of instruments, Conditioning variables not instrumented	$\chi^2(4)=$ 2.065	(0.7237)
Hausman test of Exogeneity of conditioning variables	$\chi^2(4)=$ 16.853	(0.002 0)
Cereals:		
Sargan test of Exogeneity of instruments, Conditioning variables instrumented	$\chi^2(4)=$ 6.554	(0.1614)
Sargan test of Exogeneity of instruments, Conditioning variables not instrumented	$\chi^2(4)=$ 1.623	(0.8045)
Hausman test of Exogeneity of conditioning variables	$\chi^2(4)=$ 8.163	(0.0857)
Other Products:		
Sargan test of Exogeneity of instruments, Conditioning variables instrumented	$\chi^2(4)=$ 2.086	(0.7198)
Sargan test of Exogeneity of instruments, Conditioning variables not instrumented	$\chi^2(4)=$ 4.394	(0.3552)
Hausman test of Exogeneity of conditioning variables	$\chi^2(4)=$ 4.129	(0.3887)

Note: Budget instrumented in all cases.

The results in table 1 indicate that exogeneity of the instruments used is accepted for all models at at least a 10% level. When testing exogeneity of the conditioning variables we reject this clearly for dairy products while accepting exogeneity at the 5% level for cereals and clearly accepting exogeneity of conditioning variables for other products.

In table 2 we present tests of separability for both models for each of the three food types.

Table 2: Test of separability

	Test statistic		(P-value)
Dairy Products:			
Conditioning variables instrumented *	χ^2 (4)=	79.852	(0.0000)
Conditioning variables not instrumented	χ^2 (4)=	62.181	(0.0000)
Cereals:			
Conditioning variables instrumented	χ^2 (4)=	67.634	(0.0000)
Conditioning variables not instrumented *	χ^2 (4)=	36.396	(0.0000)
Other Products:			
Conditioning variables instrumented	χ^2 (4)=	86.026	(0.0000)
Conditioning variables not instrumented *	χ^2 (4)=	51.690	(0.0000)

* indicates the statistically preferred model (see table 1). In appendix 3 parameter estimates and a summary elasticity table are presented for these models.

As seen in table 2 we reject separability clearly for all three food types irrespective of whether conditioning variables are instrumented or not and conclude that the food type separability specification (utility model (3)) is clearly inconsistent with our data. We therefore move to investigation of the general attribute specification (utility model (5)).

System estimation and testing for general attributes

The general AIDS system for household *h* consists of six budget share equations (one for the organic variant and one for the non-organic variant of each of the three food types) with the following form:

$$w^{ikh} = \eta_{ikh} + \sum_t \omega_{ikt} D^t + \sum_j \sum_{r=o,c} \gamma_{ikjr} \ln p^{jrh} + \beta_i \ln(y^h / a(p^h)) \tag{25}$$

As above η_{ikh} is the household specific fixed effect for budget share *ik,* D^t are time period dummies and ω_{ikt} the corresponding parameters for budget share *ik*. The log price index becomes:

$$\ln a(p^h) = \sum_i \sum_{k=o,c} (\eta_{ikh} + \sum_t \omega_{ikt} D^t) \ln p^{ikh} + \sum_i \sum_{k=o,c} \sum_j \sum_{r=o,c} \gamma_{ikjr} \ln p^{ikh} \ln p^{jrh} \tag{26}$$

Again we assume homogeneity and symmetry and estimate by iterating with mean corrected variables updating the price index after each iteration. When estimating we assume that prices are exogenous while the budget *y* may be endogenous and therefore is instrumented using total expenditures on daily goods for the household as above. The Sargan test for exogeneity of surplus instruments indicates that exogeneity of instruments is accepted. The estimated model is highly significant with expected signs of predicted budget shares for almost all observations and for own price elasticities in all cases for over 90% of the observations, and budget elasticities typically for over 75% of the observations (see table 3).

Table 3: Hicks (compensated) own and cross-price elasticities for the system estimation

	Dairy products		Cereals		Other products		Budget
	Org	Non-org	Org	Non-org	Org	Non-org	
Dairy org							
Mean	-0.511	0.539	0.126	0.436	0.276	-0.8659	-0.017
Median	-0.785	0.288	0.067	0.225	0.140	0.1084	0.625
%>0	10.805	99.045	99.045	99.045	99.045	56.4794	74.813
Dairy non-org							
Mean	0.120	-0.657	0.046	0.168	0.077	0.2462	0.774
Median	0.099	-0.694	0.037	0.157	0.059	0.3347	0.817
%>0	100.000	0.449	100.000	100.000	100.000	89.9251	99.419
Cereals org							
Mean	0.174	0.309	-0.566	0.590	0.138	-0.6450	0.154
Median	0.167	0.290	-0.635	0.518	0.132	-0.4450	0.282
%>0	99.045	99.045	13.296	99.045	99.045	25.7678	64.064
Cereals non-org							
Mean	0.146	0.270	0.133	-0.636	0.069	0.0184	0.718
Median	0.124	0.253	0.111	-0.695	0.051	0.1494	0.774
%>0	100.000	100.000	100.000	1.311	100.000	70.0375	98.708
Other org							
Mean	0.126	0.203	0.046	0.115	-0.820	0.3295	0.785
Median	0.207	0.288	0.079	0.164	-0.702	-0.0117	0.597
%>0	98.839	98.839	98.839	98.839	9.831	49.1573	81.835
Other non-org							
Mean	0.019	0.067	-0.006	0.020	0.011	-0.1105	1.124
Median	0.006	0.063	-0.011	0.018	-0.001	-0.1102	1.120
%>0	55.524	89.925	24.813	70.037	47.996	2.7528	100.000

Note: The mean, median and standard deviation of the distribution of observation elasticities and the proportion of positive elasticities are reported for all demand price combinations.

As noted own price elasticities have the expected negative sign for most observations while cross-price elasticities tend to be positive. We also see positive budget elasticities and systematically smaller budget elasticities for organic goods than for corresponding non-organic goods.

From casual observation we see generally positive within food type cross prices (one implication of the general attribute specification) and except for diary cereals a tendency toward relatively higher cross-price elasticities between organic than non-organic variants (the other implication of the general attribute specification). For our formal test each household is evaluated at mean household exogenous variable values and each of the 6 test conditions (3 within food type cross-price elasticities and 3 cross-price elasticity ratio tests). For each of the two types of tests the number of satisfied conditions is summed over all households (with 3 being the maximum number of passes per household for each of the two test types). The total number of passed tests as a percentage of the total number of test evaluations is reported for each test type in the first line of table 4 labelled unconstrained model (a detailed table of test results can be found in appendix 4). We see that almost two thirds of the ratio conditions are satisfied and that almost 90% of the within food type conditions are satisfied.

Table 4: Consistency with general effects specification

Model:	% Satisfied within food type conditions:	% Satisfied elasticity ratio conditions:	Test against unconstrained model	
			Test stastistic	(P-value)
Estimated (unconstrained) model	89.9%	61.1%		
Constrained model 1	87.1%	71.2%	$\chi^2(3) = 0.214$	(0.9751)
Constrained model 2	82.9%	91.8%	$\chi^2(3) = 1.752$	(0.6254)

Note: Symmetry and homogeneity imposed in all models.

In the following lines of table 4 we report corresponding results from models where parameter constraints that increase the number of households that pass the general attribute tests were imposed using minimum distance. The minimum distance procedure (see e.g. Johnston and Dinardo (1997)) uses the original system parameter ($\hat{\theta}$) and covariance ($\hat{V}$) estimates to find the set of constrained parameters (ω) that minimize $\chi^2 = (\hat{\theta} - \omega)'\hat{V}^{-1}(\hat{\theta} - \omega)$. We impose 3 constraints – one for each of the ration combinations: dairy-cereals, dairy-other and cereals-other. The constraints all have the form:

$$\frac{s_{jo}^{io}}{s_{jo}^{ic}} > \frac{s_{jc}^{io}}{s_{jc}^{ic}}$$

corresponding to the dominating constraint for which we test (i.e. the (r1) constraint in appendix 1 turns out to be the relevant constraint for most observations in all three test ratios). Constraints are tightened with each new constrained model (i.e. as we move down in table 4). Intuitively the procedure finds the set of parameters – among those sets ensuring a certain level of test passing – that minimizes the statistical difference from the unconstrained parameter estimates. The χ^2 value follows a chi-squared distribution with the degrees of freedom equal to the number of constraints (3 in our case). The minimum distance procedure is a convenient way of imposing complex constraints (avoiding complicated re-estimation) while giving a test statistic that allows us to evaluate significance of the imposed constraints.

We see from table 4 that one can impose constraints that increase the rate of passed elasticity ratio tests to over 90% (with only a small drop in the pass rate of within group cross-price elasticities). Thus, the estimated model does not differ statistically from a model where almost all cross-price restrictions implied by general organic attributes are satisfied. We conclude that the estimated system is characterized by organic crowding out in a majority of evaluation points and that we cannot reject a model characterized by organic crowding in over 90% of the evaluation points. This and the fact that within food type cross-price elasticities are positive in over 80% of the relevant evaluation points for all models leads us to the conclusion that our data (and the estimated model) is consistent with the general organic attribute specification (utility model (5)). It is, however, important to stress that we cannot rule out the possibility that some other utility function structure has generated the observed pattern of price effects.

Some implications

The empirical evidence against the separability assumption is firm. This implies that systems estimated on our data assuming separability will be biased.

The presence of organic crowding out and positive within food type cross-price elasticities are evidence in support of general organic attributes – even though other utility specifications could also have generated this pattern. A general knowledge of the structure of consumer utility functions may be useful in a number of settings. One might, for example, expect that organic food promotion campaigns focusing on general organic attributes could be effective if general organic attributes (as our results suggest) are important for household behaviour. If general organic attributes, on the other hand, were not important for consumer behaviour then promotion campaigns might be more effective if they focused on food specific attributes.

The detected presence of organic crowding out (irrespective of the specific utility structure that has generated it) may in itself have important policy implications. As noted in the introduction previous studies indicate that organic price premium reductions have a substantial effect on the organic market shares in most food submarkets. However, organic crowding out could cause the potential for increasing the aggregate organic food share through price premium reductions to be substantially lower. When comparing the compensated elasticities presented in table 3 it must be noted that most other studies present uncompensated elasticities estimated on less aggregated food type groups. Our non-organic aggregates will typically include more food types where no organic variant is available so that non-organic own-price and cross-price elasticities ceteris paribus will be smaller in our estimation because of the aggregation level of our data. This, on the other hand, is not a likely explanation of the substantially lower organic own-price elasticities that we find since non-organic variants exist for essentially all organic food types on the Danish market[14]. One possible explanation is that the food type studies in other papers have higher own-price elasticities than the average elasticity of food types in our aggregates. It is also possible that the underlying elasticities of disaggregated food types in our study correspond to those found in other studies, but that the lower own-price elasticities for the organic aggregates found in our study are caused by organic crowding out within the aggregated groups.[15]

In table 5 we present the effect on consumption of subsidising organic food. The first column shows the per cent increase in aggregate organic quantity (sales evaluated at pre-subsidy prices) which results from a 1 per cent reduction in all organic prices. In the following column the same aggregate subsidy expenditure as implied in the first column is

14 Note also that for organic foods with small budget shares the difference between compensated and uncompensated elasticities is negligible.

15 If general organic attributes are closer substitutes when they are associated with foods whose food type attributes are close substitutes then the organic substitution effect may be stronger within the food aggregates modeled here than between then.

used to subsidize organic dairy prices while other organic prices are unchanged. In the following columns this expenditure is used to subsidize organic cereals and other organic products.

Table 5: Effects of subsidies on organic demand

% increase in total organic quantity consumed	**Subsidies generating a 1% fall in all organic prices**	**Same subsidies expenditure allocated to reduce organic dairy prices only**	**Same subsidies expenditure allocated to reduce organic cereals prices only**	**Same subsidies expenditure allocated to reduce organic other prices only**
Unconstrained	0.659%	0.726%	0.642%	0.565%
Model 1	0.611%	0.696%	0.569%	0.506%
Model 2	0.509%	0.615%	0.460%	0.372%

Note: Effects assume constant aggregate food budget. Thus, the actual effect of a subsidy will depend on how it is financed (net income effects on consumers) and on substitution between food and other consumption.

We see that aggregate organic elasticities for the estimated unconstrained model are in fact relatively small. As expected we also see that as organic crowding out increases (moving down the table) aggregate demand effects of subsidies fall. Finally, we note that differentiating subsidies is an advantage, i.e. concentrating on dairy products is a slightly more effective way to increase aggregate organic food shares.

Turning now to the food budget elasticities reported in table 3 we found systematically smaller budget elasticities for organic goods than for corresponding non-organic goods. This finding may be a result of aggregation. If organic market shares tend to be higher for goods with low budget elasticities our finding could be caused by differences in composition of the food aggregates used in the estimation rather than reflecting differences in budget elasticities at the disaggregated level. Our result could, on the other hand, also reflect a lower budget elasticity for organic attributes than for most food type attributes. Irrespective of the cause our result suggests that organic budget shares generally fall as income rises[16]. One interesting implication is that organic farmers face less variation in demand due to income fluctuations than do conventional farmers.

Finally, as discussed above, our study has limitations regarding representativity that must be stressed. Both separability models and the full demand system model are estimated on subsets of the data. In the first column of table 6 we report the total number of households in our data that have purchased organic food and the mean organic budget share for each of the three food types. In the following columns we report the corresponding numbers for the

16 This may seem surprising since most other studies (see e.g. those surveyed in Thompson (1998) and Wier and Calverley (2002)) suggest that organic budget shares either rise with or are unaffected by income. However, many previous studies utilize cross-section information in data implying a danger that observed positive income effects are spurious, i.e. that organic budget shares are positively affected by e.g. education level, family background or other unobserved household characteristics which also may be correlated with income. One advantage of our model is that it utilizes the panel structure of data and so controls for all (also unobserved) time invariant household characteristics (captured in the fixed effects). Thus, the budget elasticities in our estimation only reflect household reactions to income changes over time (holding all time invariant household characteristics constant). Budget elasticities derived from cross-section information may also reflect differences between households in unobserved time invariant characteristics.

datasets on which the separability models and the full system model are estimated.

Table 6: Representativity of results

	Full dataset***	Dairy products separability model	Cereals separability model	Other products separability model	Full system model
Number of households*	2947	1910	1801	1982	955
Mean organic budget share**:					
Dairy products:	0.0227	0.0295	0.0268	0.0261	0.0440
Cereals:	0.0077	0.0089	0.0103	0.0091	0.0146
Other products:	0.0149	0.0176	0.0176	0.0183	0.0285

* Number of households that consume organic food in the data period.

** Mean over households weighted with mean food budget.

***As noted in the data section this dataset is representative of Danish consumers in a number of dimensions.

We see that the number of households is reduced for the separability models and substantially so for the system estimation. Further, mean organic budget shares are somewhat higher for the samples on which separability is tested and about twice as high for the sample on which the full system is estimated. Thus we cannot rule out the possibility that separability might hold for light users of Danish organic food not covered by our tests. Further, it is possible that the system estimation results for light organic users could differ from those reported here covering medium to heavy users.

It should also be stressed that our study does not allow us to characterize the general organic attributes that affect consumer behaviour. From other studies, however (see above), we know that consumers often mention healthiness and environment friendliness as typical organic characteristics, but we do not know if both or perhaps only one of these is perceived as a general attribute.

6. Conclusion

In this paper we develop a utility model allowing the consumers to derive utility from both commodity specific organic attributes and a general organic attribute which can be obtained from any type of organic commodity; and derive implications for consumer demand. If the general organic attribute exists and influences consumer behaviour it means that consumers may choose between purchasing organic milk together with conventional carrots, or conventional milk together with organic carrots, both decisions yielding the same level of the general organic attribute. Organic consumption of one commodity may therefore crowd out organic consumption of another organic commodity, in the sense that shifting from conventional to organic milk may lead consumers to shift from organic to conventional carrots.

We use data from a unique Danish micro panel where food consumption is registered on a disaggregated level and always has an indicator of whether the good is organic/non-organic to test the model empirically. The household level panel data make it possible to identify household specific parameters so that we can estimate household level demand systems. Our analysis covers Danish medium to heavy organic food consumers.

The empirical estimations provide firm evidence that there is significant substitution between different types of organic foods, and therefore reject the separability assumption for this group of consumers. This implies that systems estimated on our data assuming separability will be biased. We find that our data is consistent with organic crowding out in this part of the Danish food market. We find relatively small aggregate organic own-price elasticities on the order of minus 0.5 and find systematically lower food budget elasticities for organic foods than for corresponding non-organic foods.

If organic attributes related to specific products were the only important motive for consumer behaviour then promotion campaigns focusing on this specific types of food might increase the general organic budget share. However, the organic crowding out which we find implies that organic food promotion campaigns focusing on general organic attributes might be a more effective way of increasing organic demand. Organic crowding out also implies that subsidizing organic products is a less effective way of promoting demand for organic products. Though subsidizing a specific organic product may cause a substantial increases in the demand for this product, the general organic attributes imply close substitutability with other (and offhand very different) organic products implying that organic demand for most other foods is reduced so that the resulting net effect on organic demand is relatively small.

In principle, the non-separability could be taken even further. If the general organic attribute represents environmental benefits consumers may instead choose to cut down on power consumption or buy a more carbon friendly car. If the organic attribute represents health effects consumers may start exercising more instead of buying organic foods. Investigating this more general choice of behaviour could be an interesting route for further investigation.

Appendix 1: Cross-price elasticity restrictions with general organic attributes

From equation (20) it is clear that without the general attribute effect ($\delta\lambda^o / \delta p^{jo} = 0$) the following holds:

$$\frac{s^{io}_{jo}}{s^{ic}_{jo}} = \frac{s^{io}_{jc}}{s^{ic}_{jc}} \tag{a1}$$

From classic separability results (see e.g. Pudney (1981)) we know that compensated elasticities take the form $s^{ir}_{jk} = \Phi^i_j \frac{\delta x^{ir}}{\delta y}\frac{\delta x^{jk}}{\delta y}$ where y is total expenditures. Thus barring inferiority of food type attributes the sign of the elasticity is given by Φ^i_j so that either all four elasticities ($s^{io}_{jo}, s^{ic}_{jo}, s^{io}_{jc}, s^{ic}_{jc}$) are positive (the two food type attributes are substitutes) or they are all negative (the two food type attributes are complements). Using the structure of equation (a1) these two combinations are illustrated with signs while arrows indicate the direction that the general attribute will push the elasticity as indicated in (14). The ? in the place of the equals sign indicates that our task is to find the relationship that is consistent with the effect of introducing general attributes :

$$\frac{+^{io}_{jo}\uparrow}{+^{ic}_{jo}\downarrow} \; ? \; \frac{+^{io}_{jc}\downarrow}{+^{ic}_{jc}\uparrow} \qquad\qquad \frac{-^{io}_{jo}\uparrow}{-^{ic}_{jo}\downarrow} \; ? \; \frac{-^{io}_{jc}\downarrow}{-^{ic}_{jc}\uparrow} \tag{a2}$$

If signs do not change when the general attribute effect is introduced the following relationships must hold:

$$\frac{+^{io}_{jo}}{+^{ic}_{jo}} > \frac{+^{io}_{jc}}{+^{ic}_{jc}} \quad \text{(r1)} \qquad\qquad \frac{-^{io}_{jo}}{-^{ic}_{jo}} < \frac{-^{io}_{jc}}{-^{ic}_{jc}} \quad \text{(r2)}$$

Introducing sign changes one at a time the following sign combinations are possible:

$$\frac{+^{io}_{jo}}{+^{ic}_{jo}} > \frac{-^{io}_{jc}}{+^{ic}_{jc}} \quad \text{(r3)} \qquad\qquad \frac{-^{io}_{jo}}{-^{ic}_{jo}} < \frac{-^{io}_{jc}}{+^{ic}_{jc}} \quad \text{(r4)}$$

$$\frac{+^{io}_{jo}}{-^{ic}_{jo}} < \frac{+^{io}_{jc}}{+^{ic}_{jc}} \quad \text{(r5)} \qquad\qquad \frac{+^{io}_{jo}}{-^{ic}_{jo}} > \frac{-^{io}_{jc}}{-^{ic}_{jc}} \quad \text{(r6)}$$

where the indicated relationship always will be satisfied. With both possible sign changes occur we get the following, irrespective of our starting point:

$$\frac{+^{io}_{jo}}{-^{ic}_{jo}} \; ? \; \frac{-^{io}_{jc}}{+^{ic}_{jc}} \qquad \text{(r7)}$$

where any of the possible relationships (>,=,<) between the ratios may result.

Considering the starting point and direction of change indicated in (a2) all the nine remaining possible sign combinations cannot be generated from (a2) by introduction of the general attribute effect.

Thus, after estimating a demand system and calculating cross-price elasticities it is possible to check if the resulting sign combination for any two pairs of organic/non-organic food types could have been generated by a general organic specification and if so whether the relationship indicated above (where only (r1) and (r2) are real constraints) is satisfied.

Appendix 2: Detailed list of aggregated food groups

The aggregated group *Dairy products* consist of:
- Milk, cream, buttermilk etc.
- Butter, margarine, mixed products etc.
- Cheese
- Yogurts, crème fraîche etc.

The aggregated group *Cereals* consists of:
- Bread
- Flour, baking mixes etc.
- Oats, cornflakes and other breakfast cereals
- Spaghetti, pasta, noodles, rice etc.

The aggregated group *Other foods* consist of all other foods including e.g.:
- Coffee, tea etc.
- Frozen foods
- Canned foods
- Meat and fish
- Fruits and vegetables
- Eggs
- Juices
- Beer and wine
- Desserts and sweets

Appendix 3: Elasticities and parameter estimates from conditional models

Interpretation of elasticities should be made with care. These are unbiased but conditional on other goods not adjusting to the price change which they in reality will do. In fact Browning and Meghir (1991) conclude that "indeed, just about the only thing for which we can check [using these estimations] is separability".

Hicks (compensated) own and cross-price elasticities for conditional estimations

(The mean, median of the distribution of observation elasticities and the proportion of positive elasticities are reported for all demand-price combinations. Corresponding for budget elasticities reported in the last column)

	Dairy products		Cereals		Other products		Budget
	Org	Non-org	Org	Non-org	Org	Non-org	
Dairy org							
Mean	-0.5661	0.5661					0.6554
median	-0.6207	0.6207					0.8254
%>0	6.4299	93..5701					88.2299
Dairy non-org							
Mean	0.1808	-0.1808					1.0321
median	0.1127	-0.1127					1.0281
%>0	92.4305	7.5695					99.9917
Cereals org							
Mean			-0.5678	0.5678			0.953
median			-0.4994	0.4994			0.984
%>0			12.4547	87.5453			99.589
Cereals non-org							
Mean			0.1152	-0.1152			1.010
median			0.0758	-0.0758			1.002
%>0			85.1268	14.8732			100.000
Other org							
Mean					-0.8005	0.8005	1.004
median					-0.8040	0.8040	0.997
%>0					6.1700	93.8300	99.036
Other non-org							
Mean					0.0349	-0.0349	1.002
median					0.0189	-0.0189	1.000
%>0					86.8322	131678	100.000

Note: Following the results presented in Table 2, dairy elasticities based on estimation with instrumented conditioning variables while cereals and other products are based on estimations where conditioning variables are not instrumented.

Parameters and standard deviations from separate conditional estimations

		Dairy			Cereals			Other foods		
		beta	*(std.dev)*		Beta	*(std.dev)*		Beta	*(std.dev)*	
	Log prices:									
lpp_d_o_0m	Dairy, organic	-0.0086	*(0.008)*							
lpp_d_k_0m	Dairy, conventional	0.0086	*(0.008)*							
lpp_c_o_0m	Cereals, organic				-0.0401	*(0.0064)*	****			
lpp_c_k_0m	Cereals, conventional				0.0401	*(0.0064)*	****			
lpp_o_o_0m	Other, organic							-0.0044	*(0.0014)*	***
lpp_o_k_0m	Other, conventional							0.0044	*(0.0014)*	***
lbud_0m	Log total budget (β_i)	0.0335	*(0.0223)*		0.0001	*(0.0279)*		-0.0006	*(0.0057)*	
lpist_0m	Log AIDS price index (β_i)	-0.0335	*(0.0223)*		-0.0001	*(0.0279)*		0.0006	*(0.0057)*	
	Organic quantity shares times budget and AIDS price index($\tilde{\beta}_i$):									
lbud_dm	Dairy share* log budget($\tilde{\beta}_d$)				0.0468	*(0.0531)*		0.0158	*(0.0104)*	
lpist_dm	Dairy share* log AIDS price index ($\tilde{\beta}_d$)				-0.0468	*(0.0531)*		-0.0158	*(0.0104)*	
lbud_cm	Cereal share* log budget($\tilde{\beta}_c$)	-0.1219	*(0.0758)*					-0.0041	*(0.0094)*	
lpist_cm	Cereal share* log AIDS price index ($\tilde{\beta}_c$)	0.1219	*(0.0758)*					0.0041	*(0.0094)*	
lbud_om	Other foods share* log budget($\tilde{\beta}_o$)	-0.0553	*(0.2733)*		-0.0471	*(0.1222)*				
lpist_om	Other foods share* log AIDS price index ($\tilde{\beta}_d$)	0.0553	*(0.2733)*		0.0471	*(0.1222)*				
	Organic quantity shares($\tilde{\alpha}_i$)									
qpp_d_o_d_km	dairy products ($\tilde{\alpha}_d$)				-0.5670	*(0.5533)*		-0.2313	*(0.1294)*	*
qpp_c_o_c_km	cereal products ($\tilde{\alpha}_c$)	1.2916	*(0.8481)*					0.0204	*(0.1156)*	
qpp_o_o_o_km	other food products ($\tilde{\alpha}_o$)	0.2979	*(3.0605)*		0.1239	*(1.2737)*				
	Time dummies, period 1 is base:									
dd2m	Period 2	-0.0026	*(0.0046)*		0.0005	*(0.0063)*		-0.0022	*(0.0015)*	
dd3m	Period 3	-0.0145	*(0.0053)*	***	-0.0065	*(0.007)*		-0.0085	*(0.0017)*	****
dd4m	Period 4	-0.0133	*(0.0054)*	**	-0.0052	*(0.0068)*		-0.0108	*(0.0018)*	****
dd5m	Period 5	-0.0126	*(0.0052)*	**	-0.0004	*(0.007)*		-0.0058	*(0.0017)*	***
dd6m	Period 6	-0.0233	*(0.0053)*	****	-0.0181	*(0.0066)*	***	-0.0103	*(0.0018)*	****
dd7m	Period 7	-0.0244	*(0.0053)*	****	-0.0478	*(0.0069)*	****	-0.0039	*(0.0016)*	**
dd8m	Period 8	-0.0284	*(0.0053)*	****	-0.0419	*(0.0069)*	****	-0.0066	*(0.0016)*	****
dd9m	Period 9	-0.0290	*(0.0052)*	****	-0.0445	*(0.0067)*	****	-0.0036	*(0.0017)*	**
dd10m	Period 10	-0.0251	*(0.0054)*	****	-0.0348	*(0.0068)*	****	-0.0046	*(0.0018)*	***
dd11m	Period 11	-0.0227	*(0.0055)*	****	-0.0369	*(0.0067)*	****	-0.0061	*(0.0018)*	***
dd12m	Period 12	-0.0200	*(0.0056)*	***	-0.0356	*(0.007)*	****	-0.0014	*(0.0018)*	
dd13m	Period 13	-0.0295	*(0.0055)*	****	-0.0334	*(0.0071)*	****	0.0003	*(0.0017)*	
dd14m	Period 14	-0.0305	*(0.0055)*	****	-0.0271	*(0.0073)*	***	-0.0042	*(0.0018)*	**
R2		*0.028*			*0.054*			*0.041*		
Adj R2		*0.026*			*0.053*			*0.040*		

Note: Because of the adding up condition we exclude one equation (the organic version) from each estimation. Parameters in this equation are calculated residually using the adding up condition. The parameters refer to equations (22) to (24).

Appendix 4: General attribute tests and parameter estimates from the system model

General attribute tests for system estimations
(The percentage of households satisfying the indicated general attribute condition)

	Dairy products		Cereals		Other products	
	Org	Non-org	Org	Non-org	Org	Non-org
Dairy org Dairy non-org	100.00%					
Cereals org Cereals non-org	20.62%		100.00%			
Other org Other non-org	81.88%		80.73%		69.63%	

Note: Each household is evaluated at mean household exogenous variable values.

Parameter estimates and standard deviation, six good AIDS model.

Variable name	Description	Dairy, conventional beta	(std.dev)		Cereals, organic beta	(std.dev)		Cereals, Conventional beta	(std.dev)		Other foods, organic Beta	(std.dev)		Other foods, conventional beta	(std.dev)	
	Log prices:															
lpp_d_o_0m	Dairy, organic (γ_{dojr})	-0.0032	*(0.0045)*		-0.0037	*(0.0019)*	*	-0.0012	*(0.0033)*		-0.0015	*(0.0024)*		0.0097	*(0.0063)*	
lpp_d_k_0m	Dairy, conventional (γ_{dcjr})	0.0081	*(0.0074)*		-0.0048	*(0.0024)*	**	-0.0003	*(0.0034)*		-0.0027	*(0.0032)*		0.0029	*(0.0080)*	
lpp_c_o_0m	Cereals, organic (γ_{cojr})	-0.0048	*(0.0024)*	**	0.0016	*(0.0017)*		0.0025	*(0.0020)*		-0.0025	*(0.0014)*	*	0.0069	*(0.0035)*	**
lpp_c_k_0m	Cereals, conventional (γ_{ccjr})	-0.0003	*(0.0034)*		0.0025	*(0.0020)*		0.0112	*(0.0039)*	***	-0.0025	*(0.0024)*		-0.0097	*(0.0055)*	*
lpp_o_o_0m	Other, organic (γ_{oojr})	-0.0027	*(0.0032)*		-0.0025	*(0.0014)*	*	-0.0025	*(0.0024)*		0.0037	*(0.0023)*		0.0055	*(0.0049)*	
lpp_o_k_0m	Other, conventional (γ_{ocjr})	0.0029	*(0.0080)*		0.0069	*(0.0035)*	**	-0.0097	*(0.0055)*	*	0.0055	*(0.0049)*		-0.0154	*(0.0141)*	
lbud_0m	Log total budget (β_i)	-0.0216	*(0.0089)*	**	-0.0137	*(0.0043)*	***	-0.0108	*(0.0064)*	*	-0.0138	*(0.0067)*	**	0.0772	*(0.0148)*	****
lpist_0m	Log general AIDS price index	0.0216	*(0.0089)*	**	0.0137	*(0.0043)*	***	0.0108	*(0.0064)*	*	0.0138	*(0.0067)*	**	-0.0772	*(0.0148)*	****
	Time dummies, period 1 is base:															
dd2m	Period 2	0.0033	*(0.0027)*		-0.0003	*(0.0012)*		0.0042	*(0.0021)*	**	0.0032	*(0.0021)*		-0.0132	*(0.0045)*	***
dd3m	Period 3	-0.0013	*(0.0028)*		0.0013	*(0.0013)*		-0.0049	*(0.0020)*	**	0.0090	*(0.0023)*	****	-0.0091	*(0.0044)*	**
dd4m	Period 4	0.0054	*(0.0029)*	*	0.0039	*(0.0013)*	***	0.0001	*(0.0020)*		0.0158	*(0.0025)*	****	-0.0313	*(0.0045)*	****
dd5m	Period 5	-0.0019	*(0.0028)*		-0.0006	*(0.0012)*		-0.0024	*(0.0021)*		0.0103	*(0.0023)*	****	-0.0084	*(0.0044)*	*
dd6m	Period 6	-0.0015	*(0.0028)*		0.0039	*(0.0012)*	***	-0.0016	*(0.0020)*		0.0143	*(0.0024)*	****	-0.0233	*(0.0045)*	****
dd7m	Period 7	-0.0083	*(0.0028)*	***	0.0081	*(0.0013)*	****	-0.0087	*(0.0020)*	****	0.0097	*(0.0021)*	****	-0.0061	*(0.0044)*	
dd8m	Period 8	-0.0111	*(0.0029)*	***	0.0076	*(0.0013)*	****	-0.0083	*(0.0020)*	****	0.0154	*(0.0023)*	****	-0.0084	*(0.0045)*	*
dd9m	Period 9	-0.0114	*(0.0028)*	****	0.0065	*(0.0013)*	****	-0.0093	*(0.0021)*	****	0.0116	*(0.0024)*	****	-0.0011	*(0.0045)*	
dd10m	Period 10	-0.0037	*(0.0029)*		0.0063	*(0.0013)*	****	-0.0089	*(0.0021)*	****	0.0117	*(0.0024)*	****	-0.0115	*(0.0047)*	**
dd11m	Period 11	0.0003	*(0.0032)*		0.0067	*(0.0014)*	****	-0.0113	*(0.0022)*	****	0.0135	*(0.0024)*	****	-0.0150	*(0.0049)*	***
dd12m	Period 12	-0.0058	*(0.0031)*	*	0.0048	*(0.0015)*	***	-0.0098	*(0.0022)*	****	0.0083	*(0.0025)*	***	-0.0020	*(0.0048)*	
dd13m	Period 13	-0.0067	*(0.0031)*	**	0.0049	*(0.0014)*	***	-0.0056	*(0.0022)*	**	0.0056	*(0.0023)*	**	-0.0022	*(0.0047)*	
dd14m	Period 14	-0.0049	*(0.0031)*		0.0032	*(0.0013)*	**	-0.0090	*(0.0022)*	****	0.0090	*(0.0024)*	***	-0.0022	*(0.0047)*	
R2		*0.065*			*0.050*			*0.062*			*0.022*			*0.152*		
Adj R2		*0.062*			*0.047*			*0.059*			*0.019*			*0.149*		

Note: Because of the adding up condition we exclude one equation (Organic Dairy) from the estimation. Parameters in this equation are calculated residually using the adding up condition. The parameters refer to equation (25).

References

Aizcorbe, A.M. (1992) “A Note on Empirical Tests of Separability and the Approximation View of Functional Forms.” *Southern Economic Journal* 59 (2): 310-318.

Andersen, L.M. (2006). “Consumer Evaluation of Environmental and Animal Welfare Labelling.” Working paper from AKF, Danish Institute of Governmental Research. Available at www.akf.dk/udgivelser_en/container/2008/udgivelse_2559/# Verified January 2013.

Andersen, L.M. (2008): “Information Provision to Consumers as an Instrument of Environmental Regulation”, PhD Series No. 130 - 2008, University of Copenhagen.

Andersen, L.M. (2011): “Animal Welfare and Eggs – Cheap Talk or Money on the Counter?”, Journal of Agricultural Economics, Vol. 62, No. 3, pp. 565–584.

Beckmann, S.C.; S. Brokmose and R.L. Lind (2001) ”*Danske forbrugere og økologiske fødevarer*.” (in Danish). CBS-press, Copenhagen, Denmark.

Bjørner, T.B., L.G. Hansen and C.S. Russel (2004): “Environmental labeling and consumers’ choice - an empirical analysis of the effect of the Nordic Swan”, Journal of Environmental Economics and Management, Vol. 47, No. 3, pp. 411-434.

Blackorby, C.; D. Primont and R.R.Russell (1977) “On Testing Separability Restrictions with Flexible Functional Forms.” *Journal of Econometrics 5* (March): 195-209.

Boland, M., and Schroeder, T. (2002) “Marginal Value of Quality Attributes for Natural and Organic Beef.” Journal of Agricultural and Applied Economics 34,1:39–49.

Bonti-Ankomah, S. and E.K. Yiridoe (2006): “Organic and Conventional Food: A Literature Review of the Economics of Consumer Perceptions and Preferences.” Report submitted to Organic Agriculture Centre of Canada, Nova Scotia Agricultural College. Available at http://www.organicagcentre.ca/researchdatabase/res_food_consumer.asp (verified January 2013).

Browning, M., and C. Meghir (1991): “The Effects of Male and Female Labor Supply on Commodity Demands”, Econometrica, 59, 925-951.

Buzby, J.C. and Skees, J. (1994): “Consumers want reduced exposure to pesticides on food”, Food Review, Vol 17 No. 2, pp. 19-22.

Byrne, P.J., Bacon, J.R. and Toensmeyer, U.C. (1994): “Pesticide residue concerns and shopping location likelihood”, Agribusiness, Vol. 10 No. 6, pp. 491-501.

Cook, R. (1991): “Consumer demand for food safety-oriented marketing labels: implications for sustainable agriculture”, paper presented at the International Agricultural Economics Association Meeting, Tokyo, August.

Deaton, A. og J. Muellbauer (1980): "An Almost Ideal Demand System", *American Economic Review*, 70:312-326.

Denny, M. and M. Foss (1977): "The Use of an Approximation Analysis to test for Separability and the Existence of Consistent Aggregates." American *Economic Review* 67 (June): 404-418.

Fricke, A. and von Alvensleben, R. (1997): "Consumer attitudes towards organic food and an application of cohort analysis – 1984 – 1989 – 1994", Working Paper No. 1, Lehrstuhl für Agrarmarketing, Christian-Albrects University, Kiel.

Glaser, L.K., & Thompson, G.D. (1998, August): "Demand for organic and conventional frozen vegetables." Paper presented at the Annual Meeting of the AAEA, Nashville, TN.

Glaser, L.K., & Thompson, G.D. (2000, June): "Demand for organic and conventional beverage milk." Paper presented at the annual meeting of the WAEA, Vancouver, British Columbia.

Goldman, B.J. and Clancy, K.L. (1991): "A survey of organic produce purchased and related attitudes of food cooperatives shoppers", American Journal of Alternative Agriculture, Vol. 6 No. 2, pp. 89-95.

Goldman, S. and H. Uzawa (1964): "A Note on Separability in Demand Analysis." *Econometrica* 32: 387-398.

Gorman,W.M. (1956/1980): "A Possible Procedure for Analysing Quality Differentials in the Egg Market." *The Review of Economic Studies* 47: 843-856.

Hack, M.D. (1995): "Organically grown products: perception, preferences and motives of Dutch consumers", Acta Horticulturae, Vol. 340, January, pp. 247-53.

Huang, C.L. (1996): "Consumer preferences and attitudes towards organically grown produce", European Review of Agricultural Economics, Vol. 23 No. 3-4, pp. 331-42.

Ifoam (2005): "the ifoam norms for organic production and processing version 2005". Available at http://www.ifoam.org/about_ifoam/standards/norms.html (verified January 2013).

Ifoam (2012): "the ifoam norms for organic production and processing version 2012". Available at http://www.ifoam.org/about_ifoam/standards/norms.html (verified January 2013).

Johnston, J., Dinardo, J., 1997: "Econometric Methods", 4th Ed. McGraw-Hill, New York.

Jolly, D.A. (1991): “Differences between buyers and nonbuyers of organic produce and willingness to pay organic price premiums”, Journal of Agribusinees, Vol. 9 No. 1, pp. 97-111.

Lampkin, N.; C. Foster, S. Padel and P.Midmore (1999a): “*Organic Farming in Europe: Economics and Policy Volume 1: The Policy and Regulatory Environment for Organic Farming in Europe*.” University of Hohenheim, Stuttgart, Germany.

Lampkin, N.; C. Foster and S. Padel (1999b). “*Organic Farming in Europe: Economics and Policy Volume 2: The Policy and Regulatory Environment for Organic Farming in Europe: Country Studies*”. University of Hohenheim, Stuttgart, Germany.

Land, B. (1998): “Consumers’ dietary patterns and desires for change”, MAPP Working paper, No. 3, Roskilde University, Roskilde.

Lee L-F. and M.M. Pitt, (1986): “Microeconometric demand systems with binding non-negativity constraints: the dual approach.” *Econometrica* 54 (5): 1237-42.

Lee L-F. and M.M. Pitt (1987): “Microeconometric models of rationing, imperfect markets and non-negativity constraints.” *Journal of Econometrics* 36: 89-110.

Loureiro, M.L. and S. Hine. (2002): “Discovering Niche Markets: A Comparison of Consumer Willingness to Pay for Local (Colorado Grown), Organic and GMO-Free Products.” Journal of Agricultural and Applied Economics, 34 (3): 477–487.

Magnusson M.K., Arvola A, Hursti U, Aberg L, Sjoden P. (2003): “Choice of organic food is related to perceived consequences for human health and to environmentally friendly behaviour.” Appetite 40(2): 109–117.

Moschini, G., D. Moro and R.D.Green (1994): “Maintaining and Testing Separability in Demand Systems.” *American Journal of Agricultural Economics* 76 (Feb): 61-73.

Nimon, W., Beghin, J., 1999. “Are eco-labels valuable? Evidence from the apparel industry.” Am. J. Agric. Econ. 81, 801 – 811.

Pearson, D., Henryks, J., & Jones, H. (2011). “Organic food: What we know (and do not know) about consumers.” Renewable Agriculture and Food Systems, 26, 171-177. http://dx.doi.org/10.1017/S1742170510000499

Pudney, S.E. (1981): “An Empirical Method of Approximating the Separability Structure of Consumer Preferences.” *The Review of Economic Studies* 48 (October): 561-577.

Smed, Sinne (2005): “Demand structure and willingness to pay for organic dairy products.” Cahiers Options Méditerraneées, Vol 64:33-44. Available at http://curis.ku.dk/ws/files/38293764/demand_structure.pdf, verified January 2013.

Smed, S. and J.D. Jensen (2004). “Demand for low fat dairy product – demand for healthiness or taste?” In: Russel C.S. and S. Krarup (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.

Sylvander, B. (1993): “Conventions on Quality in the Fruit and Vegetables Sector: Results on the Organic Sector”, Acta Horticulture, 340.

Sylvander, B. and Floc'h-Wadel, A.L. (2000): “Consumer demand and production of organics in the EU.” AgBioForum, 3(2&3), 97-106. Available at http://www.agbioforum.org/v3n23/v3n23a05-sylvander.htm, verified January 2013.

Thompson, G.D., 1998: “Consumer demand for organic foods: what we know and what we need to know.” Am. J. Agric. Econ. 80, 1113–1118.

Thompson, G.D. and L.K. Glaser (2001a): “*National Demand for Selected Organic Foods in the United States*.” Paper presented at 71st EAAE Seminar ‘the Food Consumer in the early 21st Century’ Annual Meeting, Zaragoza, Spain, April 19-20.

Thompson, G.D. and L.K. Glaser. (2001b): “National Demand for Organic and Conventional Baby Foods,” Selected Paper presented at Annual Meeting of the Western Agricultural Economics Association, Logan, Utah, July 8-11

Thompson, G.D., & Kidwell, J. (1998): “Explaining the choice of organic produce, cosmetic defects, prices and consumer preferences.” American Journal of Agricultural Economics, 80(2), 277–287.

Thøgersen, J. (1998): “Understanding behaviour with mixed motives: An application of a modified theory of reasoned action on consumer purchase of organic food products.” CeSaM working paper 1998:13, Aarhus, Denmark.

Wier, M., Calverley, C. (2002): “Market potential for organic foods in Europe.” British Food Journal 104 (1), 45–62.

Wier, M. og S. Smed (2000): “Forbrug af økologiske fødevarer. Del 2: Modellering af efterspørgslen.” (in Danish). Faglig rapport fra DMU nr. 319. Available at http://www2.dmu.dk/1_viden/2_publikationer/3_fagrapporter/rapporter/fr319.pdf (verified January 2013).

Wier, M. and S. Smed (2002): ”Forbrug af økologiske fødevarer.” *Nationaløkonomisk Tidsskrift* Vol. 140 pp. 312-326. (in Danish).

Wier, M., L.M. Andersen and K. Millock (2005): “Information provision, consumer perception and values - the case of organic foods”, in: Krarup, Signe and C. S. Russell (eds.):

Environment, Information and Consumer Behaviour. Edward Elgar Publishing, pp. 161-178.

Wier, M., K.O. Jensen, L.M. Andersen and K. Millock (2008): “The character of demand in mature organic food markets: Great Britain and Denmark compared”, Food Policy, Vol. 33, No. 5, pp. 406-421.

Yiridoe, E.K., Bonti-Ankomah, S. and Martin, R.C. (2005): “Comparison of consumer perceptions and preference toward organic versus conventionally produced foods: A review and update of the literature” in Renewable Agriculture and Food Systems: 20(4); 193–205 DOI: 10.1079/RAF2005113.

Alviola, P.A., & Capps, O. Jr. (2010). Household demand analysis of organic and conventional fluid milk in the United States Based on the 2004 Nielsen Homescan Panel. Agribusiness, 26(3), 369–388.

Dhar, T., & Foltz, J.D. (2005). Milk by any other name . . . Consumer benefits from labelled milk. American Journal of Agricultural Economics, 87(1), 214–218.