Estimating Danish Consumers' Preference for Organic Foods: Application of a Generalized Differential Demand System.

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Abstract

A generalized differential demand system is used to provide a detailed demand system analysis of the organic food industry in Denmark to estimate conditional expenditure and price elasticities. The results suggest that cereals, dairy and other organic food aggregates are highly price-inelastic with the exception of the group, fruits and vegetables (FV), which is almost price unitary-elastic holding real income constant or price elastic holding nominal income constant. Also, cereals, FV, and other organic food aggregates are expenditure elastic. Dairy on the other hand is expenditure inelastic. Further, our calculated Morishima elasticity of substitution from the conditional compensated price elasticity estimates suggest that Danish organic consumers are more willing to substitute away from FV given a change in its relative price. The policy implications of the results are then addressed in the face of Danish organic conversion subsidy program.

Key words: organic food, conditional differential demand systems, 2-stage budgeting, Denmark.

Introduction

World organic food consumption has experienced unprecedented growth in recent years due to its increased accessibility in the global marketplace (Wier and Calverley, 2002; Korbert-Olesen, 2002; Wynen, 2006, pp. 238; Lockie, Lyons, Lawrence and Halpin, 2006, pp. 19). The organic market grew from US $12 billion in 1998 to US $63.8 billion in 2012 (Willer and Lernoud, 2014). Data compiled by the Research Institute of Organic Agriculture (FiBL) and the Agricultural Market Information Company (AMI) show that the organic food market in Europe increased by 9% in 2011, and it is now estimated to be 21.5 billion euros with the European Union accounting for 19.7 billion euros (Schaack, Padel and Willer, 2013). The Dutch and the Danes spent more than 10% more on organic food in 2012 than in 2010, and Germany, the largest market, had a growth rate of 9% (Schaack et. al., 2013).

The fundamental force behind the rapid growth of the organic food industry today is consumer demand (Dimitri and Greene, 2000; Lockie et. al., 2006, pp. 1). While the organic food industry was founded by producers seeking to reject chemical-intensive-farming methods, it has

been transformed into an industry driven by consumers seeking to protect their own well-being, health, and environment (Oelhaf, 1978, pp. 123; Lockie et. al., 2000; Lockie et. al., 2006, pp. 126). This burgeoning consumer interest has transformed organic food as a niche product sold in a limited number of retail outlets to one sold in a wide variety of venues: supermarkets, convenience stores, farmers market and pharmacies (Dimitri and Greene, 2000). In response to the consumer buzz, more agricultural lands and conversion subsidies are now being allocated for organic farming than before (Dimitri and Greene, 2000).

The organic food industry has experienced this unprecedented growth rates despite the enormous retail price premium it enjoys over conventional foods (Michelsen, et al. 1999). Sustainability of organic farming is somewhat dependent on output price premiums paid to organic farmers[1], which translates into the higher retail prices[2]. Rising consumer price premiums have been identified elsewhere as a threat to the organic food industry (see e.g., Wynen, 2006, pp. 240). Given this, previous research about organic food consumers centered mainly on the choices or reasons for choices (e.g., Huang, 1996; Schifferstein and Ophuis, 1998; Thompson and Kidwell, 1998; Squires, Juric and Cornwell, 2001; Gracia and Magistris, 2006; Nasir and Karakaya, 2013; Denver and Jensen, 2014) and willingness to pay for organic food commodities (e.g., Jolly, 1991; Gracia and Sanchez, 2000; Loureiro and McCluskey, 2000; Govindasamy and Italia, 1999; Loureiro and Hine, 2002; Soler, Gil and Sanchez, 2002; Wang and Sun, 2003; Grunert, 2005; Krystallis and Chryssohoidis, 2005; Batte, Hooker, Haab and Beaverson, 2007) to the neglect of a

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[1] Output price premium is widely seen as crucial to compensate organic farmers for the comparatively lower yields and higher labor costs associated with organic farming (Lockie et. al., 2006, pp.104). This therefore reflects the differences in production costs between the two farming systems (organic versus non-organic), and consumers' willingness to pay for the difference in product bought (Michelsen et. al., 1999). Elsewhere it has been argued by Oelhaf (1978, pp. 131) that the high consumer prices are largely a result of higher transportation, processing and retailing costs, plus some brand loyalty.

[2] Consumer premiums also vary a great deal and largely follow the same pattern as producer premiums (Michelsen et. al., 1999).

much needed detailed demand system analysis of the organic food industry using actual consumer-purchase data[3].

Given the large consumer/retail price premiums of organic foods and the relatively small market share they currently enjoy, estimates of consumers' responsiveness to price changes are needed (Thompson, 1998). Relatively few studies have incorporated organic foods in their country-level food demand analysis to estimate their expenditure and price elasticities, and much of it is needed. Even where such related studies have been undertaken, they were either applied to disaggregate dairy products such as different organic milk and their conventional type (Glaser and Thompson, 2000 for US; Wier, Hansen and Smed, 2001 for Denmark; Jonas and Roosen, 2008 for Germany; Schröck, 2012 for Germany) or disaggregate vegetables and their corresponding conventional type (e.g., Glaser and Thompson, 1998 for US) using national-level supermarket scanner data. These studies are further discussed in the next section. None of these studies to the best of our knowledge examined the within group demand relationships of different organic foods or their aggregates.

In this paper, we attempt to provide a detailed demand system analysis of the organic food industry in Denmark to estimate conditional expenditure and price elasticities using aggregated comprehensive annual survey data of supermarket chains, department stores, and wholesale chains from 2003 to 2013. We use two-stage budgeting to estimate a conditional demand system for four Danish organic food aggregates. We accomplish this by choosing the appropriate functional form to fit the data using differential approach to systemwide demand estimation (e.g., Lee, Brown and Seale, 1994; Tridimas, 2000; Schmitz and Seale, 2002). We know more about demand for food in

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[3] This neglect might be attributed to lack of adequate and reliable data in the early stages of the industry (Glaser and Thompson, 1998, 2000).

general, and specifically how organic foods interact with conventional foods (see the next section), but we know little empirically about demand elasticities of different organic foods and their substitution patterns. That this knowledge is relevant is hard to overemphasize. For instance, such an analysis is highly relevant given the fact that demand elasticities are of considerable interest for agricultural policy purposes, especially for welfare analysis of farm programs. The organic food industry in Europe in general and Denmark in particular continues to enjoy enormous governmental support to help farmers convert from conventional farming to organic farming (Michelsen, 1999; Lockie et. al., 2006, pp. 74; Wynen, 2006, pp. 240). Proper evaluation of such governmental and state supports require reliable estimates of quantity demanded responsiveness to prices and expenditures. For instance, given that the demand facing organic producers and retailers is highly price inelastic, what does this imply for Danish government effort to increase supply of organic foods vis-à-vis the welfare of the farmers? Also organic farmers, wholesalers, distributors, food processors and retailers in Denmark need to forecast demand to plan their production and sales, and demand elasticities are of crucial importance (Rickertsen, 1998).

The results from the conditional demand system estimation suggest that cereals, dairy and other organic food aggregates are highly price-inelastic with the exception of the group, fruits and vegetables (FV), which is almost price unitary-elastic holding real income constant or price elastic holding nominal income constant. Also, cereals, FV, and other organic food aggregates are expenditure elastic. Dairy on the other hand is expenditure inelastic. Further, our calculated Morishima elasticity of substitution from the conditional compensated price elasticity estimates suggest that Danish organic consumers are more willing to substitute away from FV given a change in its relative price.

The rest of the paper is organized as follows. In the next section we review works related to organic food demand analysis. Section 3 discusses the development and growth of the Danish organic food market. Section 4 presents the theoretical and empirical models for the choice of functional form to fit our data. Section 5 discusses data sources and limitations. Parametric estimation and testing procedures are taken up in section 6. Section 7 presents results analyses from section 6. Section 8 discusses the welfare implications of the Danish organic conversion subsidy program vis-à-vis our conditional own-price elasticity estimates. Section 9 concludes the paper.

2. Previous Studies

Previous researches about organic foods have centered mainly on consumer choice and willingness to pay to the neglect of a much needed and detailed demand systems analysis of the organic food industry[4]. Relatively few studies have incorporated organic foods in their food demand analysis to estimate expenditure and price elasticities. Where such related studies have been done, they were either applied to disaggregate dairy products or vegetables in addition to their corresponding conventional type.

Glaser and Thompson (1998) examined and compared demand for organic and conventional frozen vegetables using monthly national supermarket scanner data for 1996 for US consumers. Price and expenditure elasticities were estimated using the almost ideal demand system (AIDS). They found frozen organic vegetables to be more price elastic than their conventional type. Also Glaser and Thompson (2000) applied the same estimation procedure and data from

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[4] See above for cited works.

Glaser and Thompson (1998) to estimate price and expenditure elasticities for organic and conventional milk. They found organic milk to be price elastic.

Wier, Hansen and Smed (2001) applied the AIDS using Danish consumer scanner data of approximately 2,300 households from 1997 to 1998 to estimate price and expenditure elasticities for aggregated organic and conventional dairy products. They found organic dairy products to be highly price elastic. Dhar and Foltz (2005) used the quadratic almost ideal demand systems (QAIDS) to derive price and expenditure elasticities for recombinant bovine somatotropin (rBST) free and organic milk. This analysis was based on weekly US supermarket scanner data from March 1997 to February 2002. They found organic milk to be price elastic.

Jonas and Roosen (2008) analyzed the demand for organic and conventional milk consumed by German households using a panel supermarket scanner data from 2000-2003 to estimate conditional expenditure and price elasticities. Given the censored nature of their data, the authors estimated the demand system in a two-step procedure using a linear approximate almost ideal demand system (LA/AIDS). First, they used a probit regression to determine the probability that a given household will consume the good in question. The probability was then used as an instrument that incorporates the censoring latent variables in the second-stage estimation of the LA/AIDS. They found own-price elasticities of conventional milk with retail and brand labels to be almost unitary but that of organic milk to be highly price elastic. Alternatively, Schröck (2012) used a household panel dataset of 20,000 German households to estimate own-price elasticities for organic and conventional milk. The author employed the two-step estimation procedure of Jonas and Roosen (2008) to the data. In contrast to Jonas and Roosen (2008), Schröck found the own-price elasticity for organic milk to be inelastic. Alviola and Capps (2010) used a Heckman two-step estimation procedure to estimate price and expenditure elasticities for organic and

conventional milk. Using 2004 U.S. consumer scanner panel consisting of over 38,000 households, the authors found organic milk to be highly price elastic.

One interesting trend in all the above-mentioned reviewed studies is the incorporation of both organic and their conventional food type in their demand analysis. Also they all used consumer scanner data. While some corrected for sample selection bias (e.g., Jonas and Roosen, 2008; Alviola and Capps, 2010; Schröck, 2012), others (e.g., Glaser and Thompson 2000; Wier, Hansen and Smed, 2001; Dhar and Foltz 2005) did not. Also, organic versus conventional milk dominates the literature. Our demand analysis differs from the above studies in a number of ways. First, our study is for organic food aggregates alone without their conventional type[5]. Second given the richness of our data (comprehensive annual survey data of supermarket chains, department stores and wholesale chains), our estimation procedure is different[6]. Lastly, we base our elasticity analysis on both compensated and uncompensated price elasticities.

3. Danish organic market: Development and growth

The Danish organic market is well suited for consumer demand system analysis. The industry is well mature, meaning that it does not suffer seriously from the supply shortages (Wier, Hansen and Smed, 2001; Danish Ministry of Food, Agriculture and Fisheries (DMFAF), 2012) which have plagued other organic markets. The well-functioning Danish market makes it possible to collect and analyse reliable data on purchases (Wier, Hansen and Smed, 2001). The first organic

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[5] Such level of analysis is necessary in the face of the recent spike in organic food consumption. This suggests that there might be some consumers who are shifting to only organic food consumption or organic food forms a greater share of their food budget. This group of consumers is what Oelhaf (1978) refers to as "minority within the minority". This minority might be increasing given the rapid rise in mass media coverage of organic food and agriculture during the late 1900s and early 2000s (Lockie et. al., 2006).

[6] We do not have to deal with sample selection bias since our data is aggregated across retail and wholesale outlets. We also perform functional form choice analysis to find the appropriate functional form to fit the data rather than using LA/AIDS as widely used in the literature.

carrots were sold in the Danish retail stores in 1982 (Organic Denmark, 2013). It was not until 1987 that the first actual legislation governing organic production was passed with the Danish state-controlled organic inspection label, the red Ø-label, introduced two years later (Organic Denmark, 2013). Denmark was the first country in the world to pass a law on organic farming and to introduce government inspection of the organic production chain (DMFAF, 2012). Demand for organic foods was limited and low for a while. However in the summer of 1993, organic food consumption spiked when the retail chain, SuperBrugsen, offered massive price reductions combined with considerable marketing efforts (Wier and Calverley, 2002; Organic Denmark, 2013). This was followed by other similar actions by other retail chains leading to price reduction of between 15-20% for organic foods (Wier and Calverley, 2002). These actions boosted organic food consumption till 1999, when the market stagnated due to lack of product innovation (Organic Denmark, 2013). The increased marketing efforts by the retail chains occurred simultaneously with increased governmental budgetary earmarks for marketing and subsidies for farmers switching to organic production (Organic Denmark, 2013).

The above-mentioned efforts coupled with increased consumer confidence in the Ø-mark that the standards governing organic foods were adhered to (DMFAF, 1999), led to resurgence in organic food sales after the 1999 stagnation (Organic Denmark, 2014). Data from Statistics Denmark, the official Danish statistical agency, indicate that between 2003-2007 sales of some selected organic foods showed persistent percentage increase peaking at 33 percent in 2007 from 2006[7]. Between 2003 and 2013, total sales of those selected organic food had increased from approximately 2 billion DKK to around 5.8 billion DKK (figure 1a)[8]. Also, within the same time
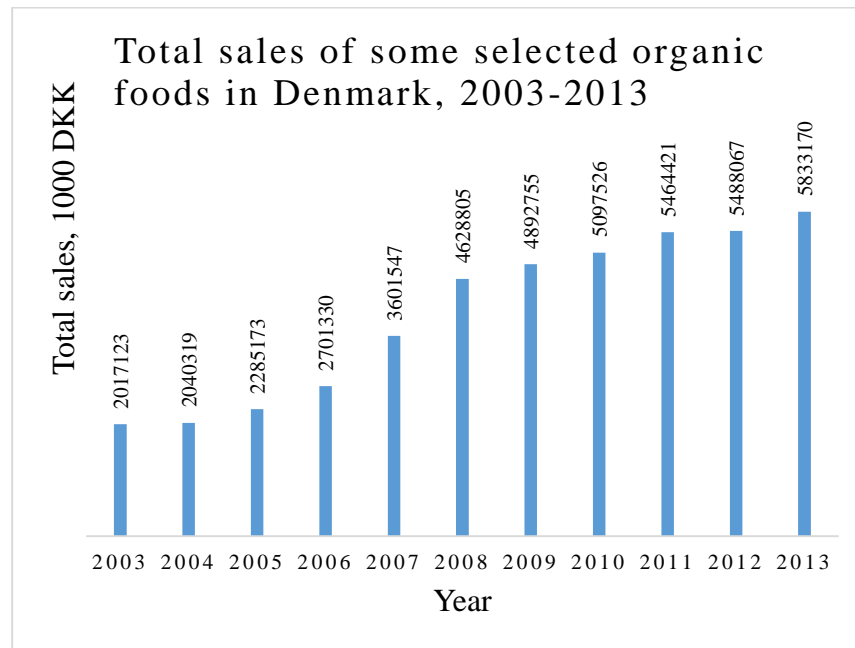
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[7] Details of the data are provided below.
[8] Danish Kroner.

period, total quantity sold of those products increased from approximately 154 thousand tons to around 248 thousand tons (figure 1b).

(a)

Total sales of some selected organic foods in Denmark, 2003-2013

Total sales, 1000 DKK

Year	
2003	2017123
2004	2040319
2005	2285173
2006	2701330
2007	3601547
2008	4628805
2009	4892755
2010	5097526
2011	5464421
2012	5488067
2013	5833170

Source: Created from data from Statistics Denmark

(b)

Total quantity sold of some selected organic food in Denmark, 2003-2013

Quantity sold, tons

Year	
2003	154372
2004	154653
2005	168454
2006	186817
2007	210639
2008	233649
2009	256118
2010	267019
2011	264361
2012	240912
2013	248086

Source: Created from data from Statistics Denmark
Fig. 1: Total sales and volume of some selected organic food in Denmark

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4. Theoretical and Empirical Modelling

Two-stage budgeting

Examining demand system relationships for commodities and services available to our representative consumer require thousands of equations, which would in turn require huge quantities of data and computer memory (Edgerton, 1997). The tradition in applied demand studies is to assume a priori some sort of structure on the consumer's preferences (Edgerton, 1997; Rickertsen, 1997). The usual assumption is that of weak separability and multistage budgeting decision process (Theil, 1975; Barten, 1977; Edgerton, 1997, Rickertsen, 1997; Carpentier and Guyomard, 2001). Thus, given that n goods are divided into a number of groups that are appropriately separable in the consumer's utility function, it turns out that demand for members of a given group can be analyzed independently (Theil and Clements, 1987, pp.163).

We use two-stage budgeting to estimate a conditional demand system for four organic food aggregates for Danish consumers. Let the unconditional ordinary demand function of n commodities be represented as

$$\mathbf{q} = \mathbf{h}(\mathbf{p}, m)$$

where $\mathbf{q}$ is $n \times 1$ vector of commodities such that $\mathbf{q} \in R_+^n$, p is the corresponding $n \times 1$ vector of prices and m is exogenous total expenditure such that $m = \mathbf{p`q}$. Applying two-stage budgeting to our n commodities implies that our representative consumer can allocate m among $G < n$ "separate" broad groups of commodities written as $S_1, \dots \dots , S_G$ in the first stage, which can be formally expressed as

$$\mathbf{q_g} = \mathbf{f}(\mathbf{p_g}, m_g) \ , g = 1, \dots \dots \dots . S_G$$

where $\mathbf{q_g}$ and $\mathbf{p_g}$ are $k \times 1$ subvectors of $\mathbf{q}$ and $\mathbf{p}$, respectively, for each group, S_g, $\mathrm{m_g}$ is the group's budget share and $\mathbf{p_g}$ is the true cost of living index for each group, S_g. The usual way of aggregating commodities into groups is to combine related commodities (Barten and Turnovsky, 1966), and this is shown in Figure 2 below. In the second stage, our representative consumer then allocates $\mathrm{m_g}$ among i elementary commodities in each group[9]. This is also formally expressed as

$$q_i = \psi(p_i, m_g) \, , \, i = 1, \dots\dots\dots.S_g \tag{1}$$

where q_i and p_i are elementary commodities and prices respectively within group S_g, $\mathrm{m_g}$ is total expenditure spent on goods in S_g. In this paper, there are four elementary organic food aggregates. We believe that Danish consumers can weakly separate their conventional food at-home purchases from organic food at-home purchases[10]. Given weak separability, the ordinary demand functions for all commodities (cereals, dairy, FV and other products) in S_g (organic food at-home purchases) are affected in the same way by a price change of any commodity in S_G, and the effect of the price change works only through the expenditure term (Theil and Clements, 1987; Edgerton, 1997; Rickertsen, 1997).

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[9] Elementary commodities used here are aggregates. This is done to save on degrees of freedom in an interpretable way. In other words given the limited time series of our data, economy of parameters is a must. (Barten and Turnovsky, 1966; Barten, 1993).

[10] "For the organic food consumer, food is a differentiated product…In addition to being organically raised, organic food often has two other quality dimensions that differentiate it from conventional food: freshness and physical proximity of the grower" (Oelhaf, 1978, pp. 138).
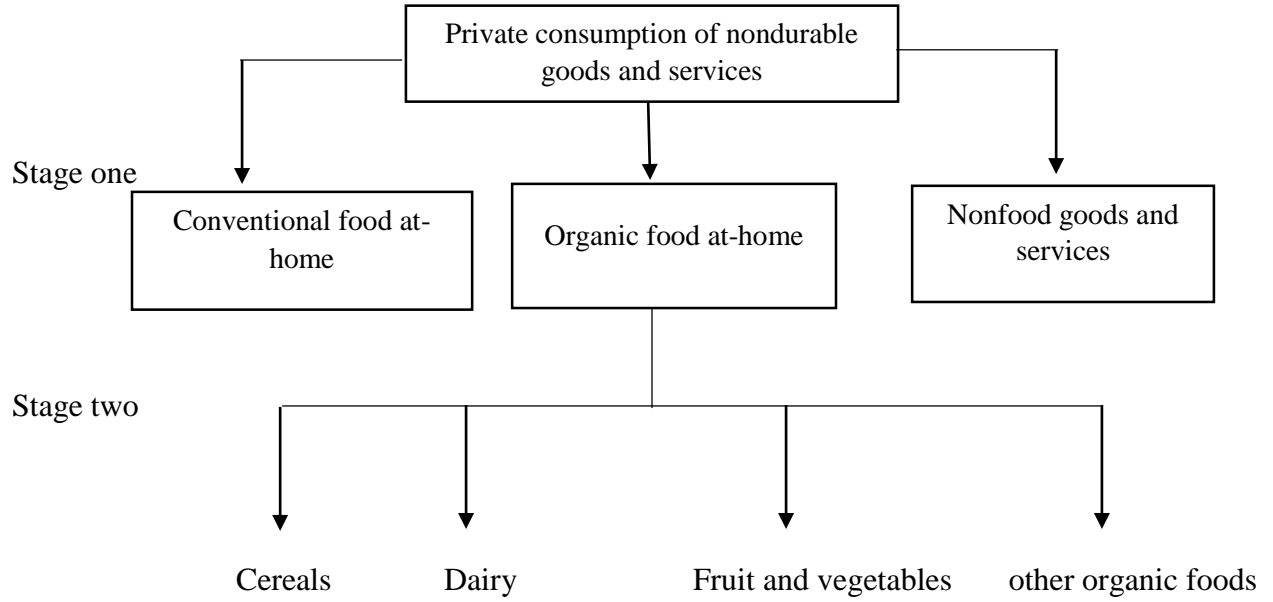
Fig. 2. Partitioning of organic food commodities

Empirical Models

The conditional demand equation (1) can be estimated under different econometric specifications. These specifications are developed under the systemwide approach to consumer demand with two-stage budgeting. Following Barten (1964), Theil (1965), Barten and Turnovsky (1966), and using notations from Theil and Clements (1987), the conditional differential demand system can be formally expressed as

$$w_{it}^* d(log q_{it}) = \theta_i^* d(log q_{gt}) + \sum_{j \in S_g} \pi_{ij}^* d(log p_{jt}) , \quad i \in S_g \qquad (2)$$

where $w_{it}^* = \frac{w_{it}}{w_{gt}}$, $\theta_i^* = \frac{\theta_i}{\theta_g}$ and $\pi_{ij}^* = \frac{\phi \theta_g}{w_g}\left(\theta_{ij}^* - \theta_i^* \theta_j^*\right)$, $\qquad i, j \in S_g$

Equation (2) is the conditional differential time-series form of (1). Equation (2) is formulated in terms of infinitesimal changes. The estimable Rotterdam model parameterization of (2) in finite-change form is expressed as[11]

$$\overline{w}_{it}^* D q_{it} = \theta_i^* D Q_{gt} + \sum_{j \in S_g} \pi_{ij}^* D p_{jt} \ , \quad i \in S_g \tag{3}$$

where $\overline{w}_{it}^* = \frac{1}{2}(w_{i,t}^* + w_{i,t-1}^*), \quad Dq_{it} = log q_{i,t} - log q_{i,t-1}, Dp_{jt} = log p_{j,t} - log p_{j,t-1}$ and

$DQ_{gt} = \sum_i \overline{w}_{it}^* D q_{it}$ (conditional Divisia volume index). The parameters θ_i^* is the marginal budget

share of commodity i, and the π_{ij}^*s are Slutsky coefficients. The matrix $\pi^* = [\pi_{ij}^*]$ is negative

semidefinite of rank n-1. The Rotterdam parameterization of (3) assumes θ_i^* and π_{ij}^* are constants.

Constant θ_i^* implies linear Engel curves. For the Rotterdam model to be a valid demand system

specification of our representative consumer, it must satisfy the following theoretical constraints,

$\sum_{i \in S_g} \theta_i^* = 1, \sum_{i \in S_g} \pi_{ij}^* = 0$ $\qquad$ Adding-up $\hfill (4)$

$\sum_{j \in S_g} \pi_{ij}^* = 0$ $\qquad$ Homogeneity $\hfill (5)$

$\pi_{ij}^* = \pi_{ji}^* \quad i, j \in S_g$ $\qquad$ Slutsky symmetry $\hfill (6)$

Empirically there is no a priori reason for the parameters of (2) to be constant. The Rotterdam model is one of the four widely used parameterization of the differential demand systems. The Central Bureau Service (CBS) model developed by Keller and van Driel (1984) combines Engel curve of the PIGLOG type with the simplicity of the Slutsky matrix, including the ease of implementing concavity and other restrictions. The total differential of the conditional budget share, $w_{it}^* = \frac{p_{it} q_{it}}{M_{gt}}$, is expressed formally as

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[11] The term 'parameterization' refers to the assumption made concerning constancy of certain parameters in the differential demand-systems (Keller and van Driel, 1984). The derivations of the other parameterizations of the differential demand systems are expressed in the finite change version. This is done without any loss of generality.

$$dw_{it}^* = w_{it}^* Dp_{it} + w_{it}^* Dq_{it} - w_{it}^* Dm_{gt}, \qquad i \in S_g \tag{8}$$

where $dw_{it}^* = w_{i,t}^* - w_{i,t-1}$, $Dm_{gt} = \log(m_{g,t}) - \log(m_{g,t-1})$. The rest of the terms are defined as bove.

Replacing the left hand side (LHS) variable of (3) with (8) and with some manipulations, one obtains the CBS model. This is expressed formally as

$$\overline{w}_{it}^* Dq_{it} = \beta_i^* DQ_{gt} + \sum_{j \in S_g} \pi_{ij}^* Dp_{jt} , \quad i \in S_g \tag{9}$$

where $\beta_i^* = \theta_i^* - w_{it}^*$ and other terms are as defined above. The following constraints of demand theory apply to the CBS model.

$$\sum_{i \in S_g} \theta_i^* = 0, \ \sum_{i \in S_g} \pi_{ij}^* = 0 \qquad \text{Adding-up} \tag{10}$$

$$\sum_{j \in S_g} \pi_{ij}^* = 0 \qquad\qquad \text{Homogeneity} \tag{11}$$

$$\pi_{ij}^* = \pi_{ji}^* \quad i, j \in S_g \qquad \text{Slutsky symmetry} \tag{12}$$

The first difference form of the almost ideal demand system (AIDS) in a time-series context as expressed in Deaton and Muellbauer (1980a), can be written, following Barten (1993), in conditional differential form as

$$dw_{it}^* = \beta_i^* dlog\left(\frac{m_g}{P_g}\right) + \sum_{j \in S_g} \gamma_{ij}^* d(logp_{jt}) , \quad i \in S_g \tag{13}$$

Replacing the LHS variable of (13) with (8) and the conditional translog price index in (13) with the conditional Divisia price index, and rewriting the resulting equation to have the same LHS variable as (3), one obtains

$$\overline{w}_{it}^* Dq_{it} = \beta_i^* DQ_{gt} + \sum_{j \in S_g} \pi_{ij}^* Dp_{jt} - w_{it}^* Dm_{gt} + w_{it}^* Dp_{it}, \quad i \in S_g \tag{14}$$

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After less tedious manipulation, (14) can be expressed as

$$\overline{w}_{it}^* Dq_{it} = (\theta_i^* - w_{it}^*)DQ_{gt} + \sum_{j \in S_g}(\pi_{ij}^* + w_{it}^* \delta_{ij} - w_{it}^* w_{jt}^*)Dp_{jt}, \quad i \in S_g \tag{15}$$

where δ_{ij} is the Kronecker delta, which equals 1 for $i = j$ and 0 otherwise. Equation (15) is the variational parameter specification of (3), such that it is the transformed form of (13) within the context of differential demand systems. The coefficients of (13) and (15) are related such that:

$$\beta_i^* = \theta_i^* - w_{it}^* \text{ and } \gamma_{ij}^* = \pi_{ij}^* + w_{it}^* \delta_{ij} - w_{it}^* w_{jt}^*$$

Consequently (15) reduces to

$$\overline{w}_{it}^* Dq_{it} = \beta_i^* DQ_{gt} + \sum_{j \in S_g} \gamma_{ij}^* Dp_{jt}, \qquad i \in S_g \tag{16}$$

Equation (16) satisfies the following constraints of demand theory:

$\sum_i \theta_i^* = 0, \ \sum_i \gamma_{ij}^* = 0$ $\qquad\qquad$ Adding-up $\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ (17)

$\sum_{j \in S_g} \gamma_{ij}^* = 0$ $\qquad\qquad\qquad\qquad$ Homogeneity $\qquad\qquad\qquad\qquad\qquad\qquad$ (18)

$\gamma_{ij}^* = \gamma_{ji}^*$ $\qquad\qquad\qquad\qquad\qquad$ Slutsky symmetry $\qquad\qquad\qquad\qquad\qquad$ (19)

Another variant of the differential demand system, known as NBR model, proposed by Neves can be obtained by replacing β_i^* in (13) with $\theta_i^* - w_{it}^*$. This can be expressed formally as

$$dw_{it}^* + w_{it}^* DQ_{gt} = \theta_i^* DQ_{gt} + \sum_{j \in S_g} \gamma_{ij}^* Dp_{jt}, \quad i \in S_g \tag{20}$$

Similarly (15) can be written to have the same LHS variables as the Rotterdam, CBS and AIDS models as

$$\overline{w}_{it}^* Dq_{it} = \theta_i^* DQ_{gt} + \sum_{j \in S_g} \gamma_{ij}^* Dp_{jt}, \quad i \in S_g \tag{21}$$

where γ_{ij}^* is as defined above. It can be noticed that the NBR model has the Rotterdam expenditure coefficient and the AIDS price coefficient. The expenditure coefficient is treated as constant while the price coefficients are allowed to vary with the conditional expenditures.

All four different parameterizations of the conditional differential demand systems have been specified with the same dependent variable[12]. In applied demand system work, the analyst is torn between choosing one of these different parameterizations. Rather than limiting oneself to a particular system and impose unnecessary restrictions on the parameter estimates a priori, test for choice of functional form is necessary. However none of the four models is a special case of another, hence the models cannot be nested. The number of coefficients of the two models may be different but one cannot reduce one set to the other by simple manipulation and as a result there is no restricted version that could act as the natural null hypothesis (Barten, 1993). Following Barten (1993) and as derived by Lee, Brown and Seale (1994), a conditional general model that nests all of the four different parameterizations can be expressed formally as[13]

$$\overline{w}_{it}^* Dq_{it} = (d_i^* - \kappa_1 w_{it}^*)DQ_{gt} + \sum_{j \in S_g}\left(v_{ij}^* - \kappa_2 w_{it}^*(\delta_{ij} - w_{jt}^*)\right)Dp_{jt} \ , \quad i \in S_g \qquad (22)$$

where κ_1 and κ_2 are the nesting parameters to be estimated. Equation (22) is therefore used as the model selection tool. The general model, (22), is considered as a demand system in its own right with two extra degrees of freedom to better adjust to the data (Barten, 1993). It, therefore, satisfies the following theoretical restrictions to be a valid representation of consumer preference:

$$\sum_{i \in S_g} d_i^* = 1 - \kappa_1, \sum_{i \in S_g} v_{ij}^* = 0 \qquad \text{Adding-up} \qquad (23)$$

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[12] (See e.g., Lee, Brown and Seale, 1994).
[13] As argued by Barten (1993) such a model is likely not to satisfy the negativity constraint of the Slutsky matrix.

$$\sum_{j \in S_g} v_{ij}^* = 0 \qquad\qquad\qquad \text{Homogeneity} \qquad\qquad\qquad (24)$$

$$v_{ij}^* = v_{ji}^* \qquad\qquad\qquad \text{Slutsky symmetry} \qquad\qquad\qquad (25)$$

From (22), the Rotterdam, CBS, AIDS and NBR models can be obtained by restricting κ_1 and κ_2 appropriately, that is,

$\kappa_1 = 0$, $\kappa_2 = 0$ for Rotterdam, model (3);

$\kappa_1 = 1$, $\kappa_2 = 0$ for CBS, model (9);

$\kappa_1 = 1$, $\kappa_2 = 1$ for AIDS, model (16); and

$\kappa_1 = 0$, $\kappa_2 = 1$ for NBR, model (21).   (26)

5. Data

Comprehensive annual organic survey data of Danish supermarket chains, department stores and wholesale chains from 2003 to 2013 are analyzed here[14]. The dataset is obtained from Statistics Denmark, the official Danish statistical agency. The retail trade sector for organic products is quite comprehensive but concentrated on very few operators (Statistics Denmark, 2014)[15]. Hence the survey is targeted at two sub-populations− supermarket chains and department stores in one group and wholesale chains in another[16]. The supermarket chains and the department stores report data on actual sales of organic commodities, together with specifications of net weight and turnover in DKK, inclusive of value added tax[17]. Similarly, the wholesale chains report data on wholesaling to the retail outlets (exclusive of sales to the above-mentioned supermarket chains

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[14] The data is available at www.statbank.dk/OEKO3

[15] This concentration implies that it is possible to reduce the total response burden imposed on the business sector without significant impact on the surveys coverage and thereby the validity (Statistics Denmark, 2014).

[16] The supermarket chains and department stores surveyed are members of Federation of Retail Grocers in Denmark. The Federation has about 1,500 retail member shops. However, it is not all member shops that sell organic products.

[17] Quantities reported by the wholesale chains, according to Statistics Denmark, were multiplied by retail price of each of the commodities to arrive at the total sales value for consistent aggregation with the retail data. However the data available at Statistics Denmark's website have no information on retail prices.

and department stores), together with specifications of net weight in tons and turnover in DKK, inclusive of VAT.

According to Statistics Denmark, members of the Federation of Retail Grocers in Denmark receive almost all of their organic commodities from the wholesale chains with the exception of fruit, vegetables and dairy products. With regards to fruits and vegetables, the wholesale chains supply half of the total quantity sold, hence the quantities reported by the wholesalers were doubled to estimate total quantity sold within the survey period. However milk is, in some cases, delivered directly to shops, which are members of the Federation of Retail Grocers in Denmark, without involving the wholesalers (Statistics Denmark, 2014). As a result, adjustments similar to above have not been made to the quantity sold of milk. Consequently, total sales of dairy products may be underestimated.

The variables used here are total sales and quantity of the organic commodities in the survey. These are converted to per capita variables using annual population level data within the sample period[18]. Per capita consumption and expenditure data are displayed below in Figures 2 and 3, respectively. Without any retail price information, unit prices of the commodities are used for this analysis. The unit prices are displayed in Figure 4 below. The commodities are aggregated based on their level of relatedness into four groups−cereals, dairy products (excluding meat), fruits and vegetables (FV), and other products. This is done to save on degrees of freedom to derive consistent estimates. Also, given the limited time series of our data, economy of parameters is a must. Table 1 reports the budget share of our four organic food aggregates for 2003, 2013, and the mean and standard deviation of the sample. From 2003 to 2013, Danish organic consumers' budget

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[18] The population data were obtained from Statistics Denmark's website.

share on cereals increased by roughly 17%, dairy products decreased by roughly 31%, FV increased by 30% and other products increased by approximately 28%. Within the same period, the unit price per ton of cereals increased by approximately 54%, dairy products increased by roughly 45%, FV increased by roughly 67% and other products increased by approximately 44%. These astronomical price increases transmitted in dampening of per capita consumption in the sample period as can be seen from Figure 1 above.

Table 1. Selected Budget Shares, Mean and Standard Deviation of Four Danish Organic Food Commodities, 2003-2013.

Year	Cereals	Dairy	FV	Other products
2003	0.119	0.451	0.142	0.287
Mean	0.134	0.355	0.176	0.336
Std.Dev.	0.021	0.055	0.020	0.021
2013	0.139	0.311	0.184	0.366

The highest mean budget share during the sample period was for dairy products (36%), followed by other products, FV, and cereals. Also, there was substantially more variation in the budget share for dairy than the other food aggregates.
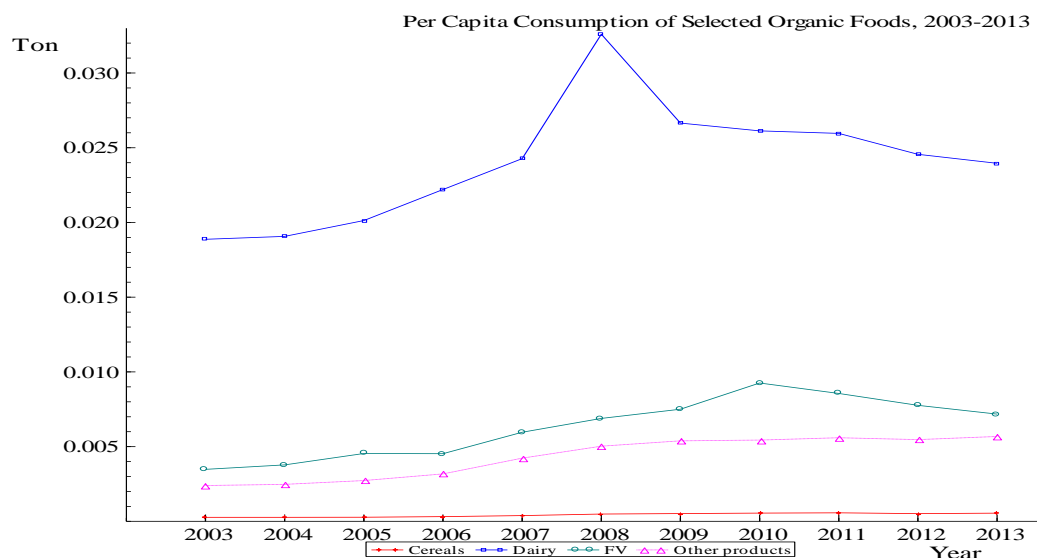
Fig. 2. Per capita consumption of selected organic food aggregates in Denmark.

Fig. 3. Per capita expenditure of selected organic food aggregates in Denmark.
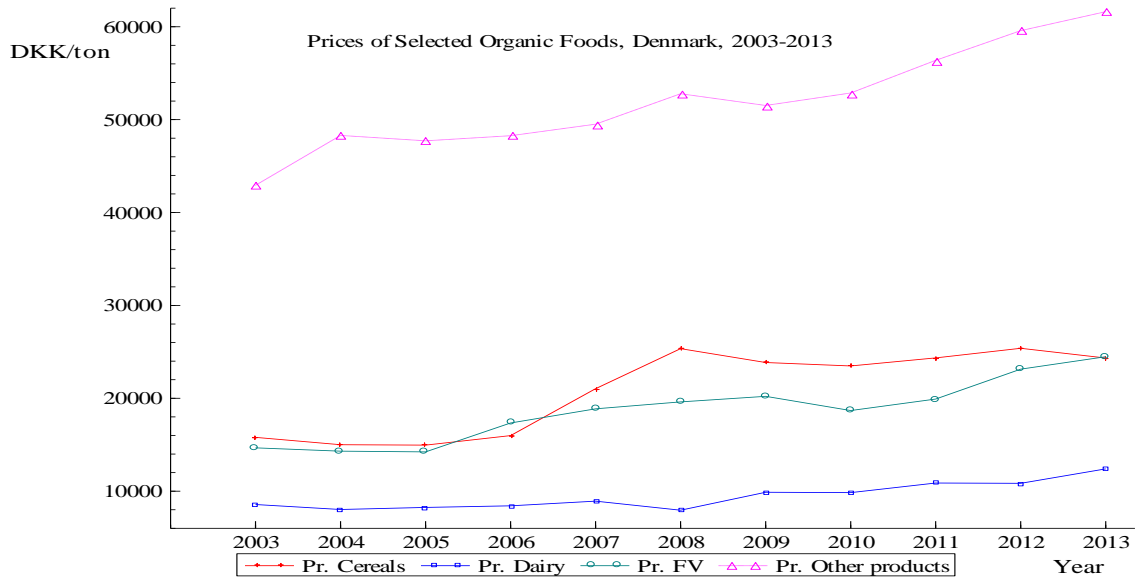

Fig. 4. Unit price of selected organic food aggregates in Denmark.

6. Estimation procedure and parametric testing

Stochastic versions of the Rotterdam, CBS, AIDS, NBR and the general models are estimated with additive error terms, u_{it}, which are a vector of random drawings from multivariate normal distribution with mean zero and covariance matrix Ω, that is,

$$E(u_{it}) = 0 \text{ and } E(u_{it}u_{it}`) = \Omega.$$

It is further assumed that

$$E(u_{it}u_{it}`) = 0 \text{ for } t \neq t`. \tag{27}$$

The last stochastic assumption implies the absence of serial correlation of the error term. Due to the adding-up property implied in demand functions, our contemporaneous covariance matrix, Ω, is singular. If (27) holds, Barten (1969) has shown that maximum likelihood (ML) estimates of the parameters in the complete n-equation system can be obtained from n-1 equations. The resultant equations yield ML parameter estimates that are invariant to the equation deleted. If, however, (27) breaks down then ML estimation of n-1 equations yield parameter estimates that are not invariant to the equation deleted. Stochastic assumption (27) is therefore tested in our study given that some empirical demand system analyses have found a breakdown of this assumption.

Given the above stochastic assumptions, all of the five conditional differential demand systems are estimated using iterative seemingly unrelated (SUR) regression (Zellner Efficient Procedure). The presence of nonlinear combinations of the elasticities to be estimated, below, in the regression specifications and in the restrictions necessitated the use of an iteration process to arrive at point estimates (Barten, 1964, 1969). This is accomplished by using LSQ command in TSP. This SUR procedure iterates over Ω and converges to the maximum-likelihood estimator, given normality of the error terms (Berndt and Savin, 1979; Rickertsen, 1997).

We first estimate unconstrained forms of model (3), (9), (16) and (21), and later constrain them by imposing homogeneity and then symmetry. The likelihood-ratio test is used to test the theoretical restrictions of homogeneity ad symmetry on each of the five models. One of the goals of this paper is to choose an appropriate functional form for the data, hence the likelihood ratio

test is also used to test restrictions (26). In other words, we test whether any of the systems nested within (21) are consistent with the data, given the maintained hypothesis that one of the differential demand systems is appropriate. The likelihood ratio test statistic is stated formally as

$$LRT = -2[LLV(\lambda^*) - LLV(\lambda)] \tag{28}$$

where $LLV(\lambda^*)$ is the log-likelihood value associated with the restricted (constrained) parameter estimates, λ^*, while $LLV(\lambda)$ is the log-likelihood value associated with the unrestricted (unconstrained) parameter estimates, λ. Under the null hypothesis and certain regularity assumptions, LRT is chi-squared distributed, with degrees of freedom equal to the number of restrictions imposed (Greene, 2012). A hypothesis is rejected when the corresponding p-value, the probability of rejecting a true null hypothesis, is less than 0.005. Moreover, following Bewley (1985) and Bewley, Young and Colman (1987), a systemwide goodness-of-fit measure is employed for the chosen functional form. This is stated formally as

$$R_L^2 = 1 - \frac{1}{1+LR/(T(n-1))} \tag{29}$$

where T is the number of observations and the likelihood ratio, LR, is twice the difference between the log-likelihood value of the chosen functional form and the log-likelihood value of the dependent variables of the chosen functional form on a constant term only.

7. Results

Tests for autocorrelation and parametric restrictions

We estimated our conditional demand systems without the demand equation for other products. Assumption (27) is checked for first-order autocorrelation, AR(1), in our data. If AR(1) is present, then $u_t = \rho u_{t-1} + \epsilon_t$ for t =2,…..,T and where $\epsilon_2, …….\epsilon_T$ are independently,

identically distributed multivariate normal random vectors with mean zero and covariance matrix Σ. Consequently, AR(1) is imposed on the data and the Hildreth-Lu method is used to search for ρ, after applying Prais-Winsten transformation to the data. The AR(1)-imposed specification is the unconstrained model since it has one more parameter, ρ, to estimate, and this should increase the likelihood value, at least significantly if the AR(1) specification is correct. This is not the case here. With homogeneity and then symmetry imposed on the AR(1) specification, for example on the Rotterdam model, ρ is -0.001 and the likelihood ratio test statistic is 2.35. The critical value at the 95% confidence level is 3.84. This clearly suggest AR(1) is not a problem in our data. Moreover, our restricted conditional differential demand systems are expressed in terms of first differences over time, and this tends to eliminate almost completely the autocorrelation in the data (see Barten, 1969, 1977). Therefore (27) is a plausible working assumption.

Next, we check the validity of theoretical demand restrictions on our five demand systems. While adding-up is readily satisfied due to the setup of the models, homogeneity and symmetry are not. Homogeneity and symmetry reflect assumptions of choice behavior from utility theory. Hence (28) is used to test the theoretical restrictions of homogeneity and symmetry on the five demand system specifications. The likelihood-ratio test statistics from (28) and the associated p-values for the test of homogeneity and symmetry on all the five models are reported in columns 1and 2, respectively, under each model in Table 2. A hypothesis is rejected when the corresponding p-value, the probability of rejecting a true null hypothesis, is less than 0.005. We reject the hypothesis of homogeneity on all the five models at the 5% significance level. According to Laitinen (1978), the standard test is seriously biased toward rejecting the hypothesis of homogeneity. Hence, we follow Laitinen's suggestion, and use Hotteling T^2 test. The 5% critical value of T^2 is 46.39, whereas the F-statistic for the Rotterdam, CBS, AIDS, NBR, and the general

models are 3.05, 3, 2.72, 2.81, and 23.7, respectively. However, symmetry imposed after homogeneity is not rejected at the 5% significance level.

Table 2. Likelihood-Ratio-Test Statistics and Corresponding *p*-Values for the Five Demand Systems.

Restriction	Model									
	Rotterdam		CBS		AIDS		NBR		General	
	LRT	*p*-Value	LRT	*p*-Value	LRT	*p*-Value	LRT	*p*-Value	LRT	*p*-Value
Homogeneity	14.000	0.003	13.868	0.003	13.136	0.004	13.365	0.004	24.859	0.000
Symmetry	1.100	0.777	0.781	0.854	1.260	0.739	1.688	0.640	1.402	0.705

Test of choice of functional form and goodness-of-fit.

Next, we present the test for choice of appropriate functional form using (28). If the restrictions specified in (26) are valid, then imposing them should not lead to a large reduction in the log-likelihood value. Table 3 reports the likelihood-ratio-test statistics (LRT) from (28) and their corresponding *p*-values for test of choice of the appropriate functional form for the data. The LRT is chi-squared distributed with 2 degrees of freedom. The unrestricted model used here is (21). The test is performed after imposing symmetry on all five models.

Table 3. Log Likelihood-Ratio-Test Statistics and their Corresponding *p*-Values for Choice of Functional Form.

Model	H$_0$	LRT	*p*-Value
Rotterdam	$\kappa_1 = 0, \kappa_2 = 0$	14.309	0.001
CBS	$\kappa_1 = 1, \kappa_2 = 0$	10.107	0.006
AIDS	$\kappa_1 = 1, \kappa_2 = 1$	10.189	0.006
NBR	$\kappa_1 = 0, \kappa_2 = 1$	14.714	0.006

Similarly, a hypothesis is rejected when the corresponding *p*-value, the probability of rejecting a true null hypothesis, is less than 0.05. When tested against the general model, all the restrictions in (26) are soundly rejected. Also the conditional estimates of the nesting parameters, $\kappa_1 = 3.732$

(0.482) and $\kappa_2 = 1.591$ (1.116), are all statistically different from zero at the 5% and 10% significance levels, respectively[19]. This probably suggests a variational parameter specification of the differential demand system, that nests all the features of the Rotterdam, CBS, AIDS and the NBR models, will do a better job of fitting the data at hand. This is consistent with Barten (1993), and Lee, Brown and Seale (1994) who argue that the general model can be used as demand system in its own right. As a result, the general model is used for further analysis. The calculated systemwide coefficient of determination, R_L^2 is 0.54 for the general model, indicating that the chosen functional form explains 54% of the variation in allocation.

Parameter estimates

The conditional parameter estimates of the general model are reported in Table 4. Instead of reporting the price coefficients of the general model which does not have an intuitive meaning, we report the Slutsky price coefficients noting that $\pi_{ij}^* = v_{ij}^* - \kappa_2(w_i^* \delta_{ij} - w_j^*)$, where w_i^* and w_j^* are the conditional sample mean budget shares. The conditional expenditure coefficients (marginal shares) are also reported using $d_i^* + \kappa_1 w_i^*$. All the conditional expenditure coefficients are positive but less than unity, and are significantly different from zero at the 5% level.

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[19] Asymptotic standard errors in the parentheses.

Table 4. Conditional Expenditure and Slutsky Price Coefficients of the General Model, Homogeneity and Symmetry Imposed.

Commodity	Expenditure Coefficient	Slutsky price coefficient			
		Cereals	Dairy	FV	Other products
Cereals	0.193^*	-0.046^*	-0.032^*	0.032^*	-0.018
	$(0.011)^a$	(0.013)	(0.011)	(0.013)	(0.017)
Dairy	0.169^*		-0.200^*	0.076^{**}	0.092^*
	(0.070)		(0.068)	(0.043)	(0.038)
FV	0.217^*			-0.166^*	0.058^*
	(0.044)			(0.046)	(0.030)
Others	0.421^*				-0.132^*
	(0.040)				(0.037)

a=Asymptotic standard errors in the parentheses
*=Significant at α=0.05
**=Significant at α=0.1

All the conditional Slutsky own-price coefficients are negative as expected and statistically different from zero at the 5% significant level. All the conditional Slutsky cross-price terms are positive and significant at the 5% level, except cereals-other products which is negative and not significant. The positive conditional cross-price coefficients indicate these goods are substitutes.

Conditional demand elasticities

The complete set of formulae to calculate conditional demand elasticities for the general model is given in Table 5, where η_i^*, ε_{ij}^{*c} and ε_{ij}^{*u} represents conditional expenditure, compensated and uncompensated price elasticities, respectively. δ_{ij} is the Kronecker delta as defined above. Since the observed budgets do not vary much over the sample period, the elasticities are calculated at the conditional sample mean, w_i^*.

Table 5. Conditional Demand Elasticities

Model	η_i^*	ε_{ij}^{*c}	ε_{ij}^{*u}
General	$\dfrac{d_i^*}{w_i^*} + \kappa_1$	$\dfrac{v_{ij}^*}{w_i^*} - \kappa_2(\delta_{ij} - w_j^*)$	$\dfrac{v_{ij}^*}{w_i^*} - \kappa_2(\delta_{ij} - w_j^*) - \dfrac{(d_i^* + \kappa_1 w_i^*)w_j^*}{w_i^*}$

The conditional demand elasticity estimates resulting from Table 5 are reported in Table 6. The first and second columns of the top panel reports the expenditure and compensated price elasticities, respectively. The bottom panel in Table 6 reports the uncompensated price elasticities. The conditional expenditure elasticities, η_i^*, are positive and significantly different from zero at the 5% level. Cereals, FV and other products are classified as luxuries given by the magnitude of their expenditure elasticities. This implies that Danish organic food consumers spend more than proportionately on cereals, FV and other organic foods given a percentage change in total expenditure on organic foods. Dairy products are least responsive to total expenditure on organic foods.

Table 6. Conditional Demand Elasticities of Four Organic Food Aggregates, Denmark, 2004-2013.

Commodity	Expenditure Elasticity (η_i^*)	Compensated price elasticity (ε_{ij}^{*c})			
		Cereals	Dairy	FV	Other products
Cereals	1.426*	-0.337*	0.237*	0.236*	-0.136
	(0.085)[a]	(0.093)	(0.083)	(0.094)	(0.124)
Dairy	0.489*	0.093*	-0.580*	0.219**	0.267*
	(0.202)	(0.032)	(0.198)	(0.125)	(0.111)
FV	1.215*	0.179	0.423**	-0.928*	0.326*
	(0.246)	(0.071)	(0.241)	(0.258)	(0.165)
Others	1.235*	-0.054	0.271*	0.171*	-0.388*
	(0.117)	(0.049)	(0.113)	(0.087)	(0.110)
		Uncompensated price elasticities (ε_{ij}^{*u})			
Cereals		-0.530*	-0.255*	-0.019	-0.622*
		(0.100)	(0.086)	(0.091)	(0.121)
Dairy		0.027	-0.748*	0.131	0.101
		(0.044)	(0.184)	(0.081)	(0.148)
FV		0.014	0.004	-1.145*	-0.088
		(0.081)	(0.225)	(0.269)	(0.199)
Others		-0.221*	-0.156	-0.050	-0.809*
		(0.074)	(0.191)	(0.124)	(0.123)

Note: Elasticities are calculated from the General model with homogeneity and symmetry imposed.
a=Asymptotic standard errors in the parentheses
*=Significant at α=0.05
**=Significant at α=0.1

The conditional own-price elasticities (ε_{ii}^{*c} and ε_{ii}^{*u}) are all negative as expected, and statistically different from zero at the 5% significant level. Given that a Danish organic consumer is compensated for a price change, the conditional own-price elasticities, ε_{ii}^{*c}, indicate that the cereals, dairy products and other organic food products are price inelastic, and FV is almost unit elastic[20]. That is, a 1% increase in the prices of cereals, dairy products and other organic foods leads to 0.3%, 0.6% and 0.4% falls in quantity demanded, respectively, while the same percentage increase in the price of FV leads to the same percentage fall in quantity demanded. On the other hand, when the same consumer is not compensated for a price change (ε_{ii}^{*u}), cereals, dairy products and other organic foods are still price inelastic but FV is price elastic. This finding is consistent with the food demand literature. Consumers are usually more price sensitive to FV than other foods. These own-price elasticities have implications on farmers' revenue and welfare. For instance, cereals and dairy organic farmers are more likely to benefit from increasing price premiums than FV farmers.

Out of the 12 conditional compensated cross-price elasticities (ε_{ij}^{*c}, for $i{\neq}j$), 10 are positive indicating substitutability among those organic food commodities. However, the dominance of substitution in the Slutsky matrix does not come from the preference structure of the consumer but is as a result of the adding-up condition, and the negativity condition of the Slutsky matrix (Barten, 1989). A more standard measure of the direction of interaction will be the Morishima elasticity of substitution (MES). MES is an exact measure of the curvature of the consumer's preference structure, that is, the ease of substitution (Blackorby and Russell, 1989). Following Blackorby and Russell (1989), a conditional MES is stated as $M_{ji}^{*} = \varepsilon_{ij}^{*c} - \varepsilon_{jj}^{*c}$. That is, the effect of the variation in the price ratio, p_i/p_j in the ith coordinate direction on the optimal quantity ratio, q_i/q_j divides

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[20] Oelhaf (1978) observed that own-price elasticities of most organic foods are inelastic.

into two parts: the (proportional) effect on q_j of varying p_i (given by ε_{ji}^{*c}) and the proportional

effect on q_i of varying p_i (given by ε_{ii}^{*c}) holding other prices and utility constant (Blackorby and

Russell, 1989). These are reported in Table 7. All the MES estimates are positive, which indicates

pairwise substitution. MES presents quite different portrayals of consumers' willingness to

substitute different types of organic foods in response to relative price changes. The magnitudes

here are intuitively more plausible than the corresponding Slutsky cross-price elasticities. For

instance, a 1% increase in the relative price ratio of dairy and cereals in the dairy coordinate leads

to an approximately 0.8% increase in the relative quantity ratio of dairy and cereals in the direction

of the cereals coordinate. However, the reverse leads to only 0.4% increase in the quantity of dairy

products. Also, FV are highly and significantly substituted with other organic foods by Danish

consumers given an increase in the price. Also, the rigidity in substituting away from cereals for a

price increase confirms cereals as a staple food in the consumer basket. Moreover, dairy products

and FV are highly substituted between each other given a price change by Danish consumers.

These patterns of substitution are not easily explained by the off-diagonals of the Slutsky matrix.

Table 7. Conditional MES for Four Danish Organic Food Aggregates, 2004-2013.

Commodity	MES			
	Cereals	Dairy	FV	Others
Cereals	0	0.816[*]	1.164[*]	0.252
		(0.218)[a]	(0.252)	(0.192)
Dairy	0.430[*]	0	1.147[*]	0.655[*]
	(0.084)		(0.353)	(0.203)
FV	0.0515[*]	1.003[*]	0	0.714[*]
	(0.145)	(0.418)		(0.214)
Others	0.283	0.850[*]	1.099[*]	0
	(0.129)	(0.299)	(0.296)	

Note: MES is calculated at the conditional sample means
a=Asymptotic standard errors in the parentheses
*=Significant at $\alpha=0.05$

8. Policy implications of the Danish organic conversion subsidy program

The limited nature of our data makes it difficult to conduct a long-run analysis of the demand for organic food, which incorporates an adjustment phase. However, this does not exclude us from making some relevant welfare policy implications out of the elasticities calculated above. This analysis is relevant to the Danish organic food sector given increased governmental earmarks to subsidize conversion to organic farming over the years[21]. Denmark is one of the countries in the world that enjoys the strongest government support for organic agriculture, in terms of subsidies for conversion to certified organic agriculture (Fuchshofen and Fuchshofen, 2000). The Danish government is committed to doubling total organically-farmed area by 2020, which will account for approximately 12% of the Danish farmland (DMFAF, 2012)[22]. The conversion subsidy in Denmark was first targeted at livestock producers in 1987 till 1994, when it was extended to cover arable crop and pig farmers (Daugbjerg, 2010). After several years of overproduction of organic milk and cereals, across the board conversion payments were introduced in 2004, of which dairy farmers were excluded till 2007 (Daugbjerg, 2010). It is not surprising that Denmark has been a net exporter of organic milk over the years. Subsidies to convert to organic farming in 2011 were 1,050 DKK per hectare per year in conversion, and 100 DKK per hectare per year in subsequent years in the commitment period (Norfelt, 2011).

Currently, demand for organic foods and products, in general, in Denmark is high, and it is expected to grow between 5-10 % in the next two years (Organic Denmark, 2013). This means that prices are expected to stay pretty much high (as seen in data displayed in Figure 4 above), at least in the short run. This is likely to translate into higher farm-gate prices for organic farmers. The conversion subsidy removes barrier to entry to organic agriculture as it entails huge sunk cost.

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[21] In addition to financial support to organic farmers, the Danish government also discouraged conventional farming by levying high taxes on products such as fertilizers and pesticides (Norfelt, 2011).
[22] The support is partly financed through the EU's Rural Development Program.

Without the conversion subsidy, price must be high enough to attract new farmers to enter, not only to provide a fair return to the resources employed but to compensate the marginal farmer for the cost of changing over (Oelhaf, 1978). What the conversion subsidy ultimately does is to shift the short-run-supply curve downwards to a price lower than what would have prevailed without the conversion subsidy. In the light of the conditional price elasticities above, increased organic food production has varying consequences on consumer and producer welfare as the distributional effects are different[23]. In other words, the type of derived demand facing organic farmers determines whether the gains from their activities accrue wholly to themselves or consumers. For instance, given that the derived consumer demand, for the sample period, for cereals, dairy and other organic foods is price inelastic, consumer rather than farmer welfare is maximized by a subsidy program to convert more farmland to production of those commodity aggregates. This finding is similar to any farm subsidy program that increases output supply. FV farmers comparatively suffer less welfare loss given the price-elastic nature of the derived demand they face.

In short, increased production and supply of organic foods is supposed to in the medium to long run, cause farm-gate prices for cereals, dairy products and other organic foods to fall more than that of FV, benefitting the consumer more than the farmer. This is likely compounded by the pressures of international organic trade given that Denmark is a net importer of most organic foods. This is interesting given that increased farmer welfare has been advanced as one of the reasons for need to subsidize organic agriculture. Figure 5 illustrates this graphically for a single organic food aggregate. Without the conversion subsidy program, the short run supply curve is S_1 at the market price P_1.

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[23] Total elasticities would have been more relevant in such policy analysis, however the data at hand do not permit such elasticities to be calculated.
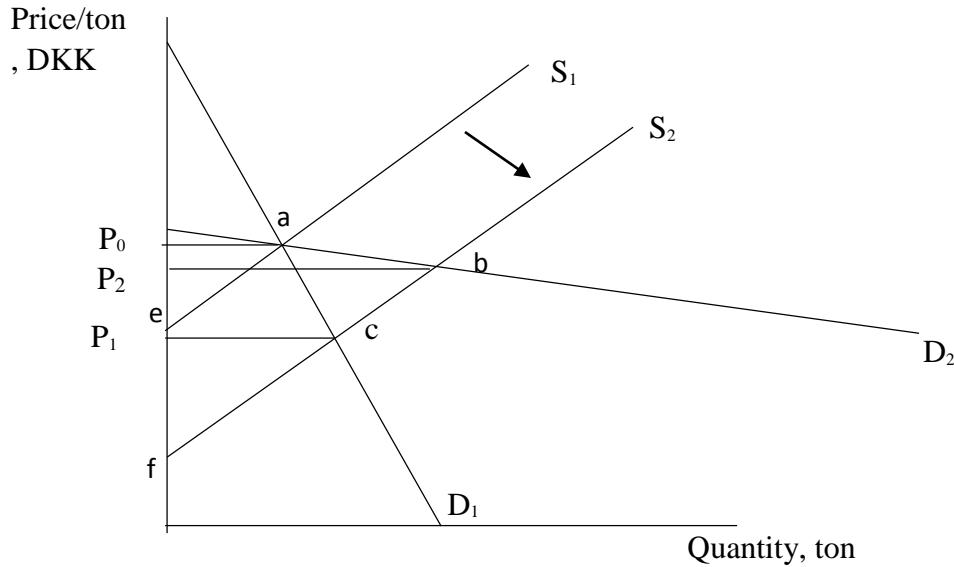
Fig. 5. Effect of organic conversion subsidy program on farmer welfare.

The conversion subsidy program shifts the supply curve to S_2 thereby reducing the market price.

From the figure below, it is clear that the extent of the price fall depends much on the price sensitivity of the derived demand of the commodity in question. Given that the derived demand, D_1 facing the commodity in question is price inelastic, like for most organic food aggregates calculated above, the price falls significantly compared to D_2, which is price sensitive ($P_2 > P_1$). Prices would not have even fallen D_2 if it is drawn to be perfectly elastic. Farm revenue plummets more under D_1 than D_2. The welfare loss for farmers facing D_1 is higher than under D_2. The producer surplus after the price change under D_2 is P_2bf, however with the organic farmer facing D_1 the producer surplus is now P_1cf. The welfare differential for the organic farmer facing D_1 instead of D_2 is P_2bcP_1. This is gained by the organic food consumers as increased consumer surplus. In the light of this, Danish organic farmers have two-options: (1) to export more of their products which organic milk farmers have been doing over the years to take advantage of higher prices elsewhere, or (2) to diversify operations with the inclusion of nonfood organic crops in their production rotations for sale to cushion the impact of declining organic food prices.

9. Conclusion

In this paper, we estimate Danish consumers' preference for four organic food aggregates. We accomplish this by first choosing an appropriate functional form to fit the data. We applied four conditional differential-demand-system parameterizations and a generalized specification that nests all the four different parameterizations, and we used the general model for model choice. The generalized model, a valid demand system in its own right, fit the data well. Hence the generalized model is used to estimate conditional demand elasticities of the four organic food aggregates. The results suggest that cereals, FV, and other organic food aggregates respond more than proportionately to a proportionate change in Danish expenditure allotted for organic food consumption. Dairy products, on the other hand, is found to be inelastic to change in organic food expenditure. Further, the own-price elasticities are negative and consistent with economic theory. Holding conditional real expenditure constant, the results indicate that cereals, dairy, and other organic food aggregates are price inelastic but the FV is unitary elastic. The same classification is obtained for cereals, dairy and other organic food aggregates holding conditional nominal expenditure constant but that FV is price elastic. Moreover our calculated Morishima elasticities of substitution reveal interesting patterns of Danish consumers' willingness to substitute different types of organic food aggregates given a change in the relative price. FV is found to be highly substituted given a change in its relative price. That these findings are relevant for policy cannot be overemphasized. For instance we found that, given the own-price elasticities, the Danish organic conversion subsidy program currently being implemented is more welfare improving for organic consumers than the farmers. This is surprising given that improvement in the welfare of the farmer has long been cited as one of the main reasons for the need to subsidize farmers to switch to organic farming.

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