Consumer valuation of health attributes in food

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Abstract

In modern societies it seems that the pleasures of taste often encourage the consumption of fatty, salty and sweet foods, whereas growing health awareness discourages consumption of the same foods. Numerous studies find that education and diet healthiness are highly correlated and one possible explanation is that consumers with a longer education are better at understanding and appreciating the health implication of their diet than are consumers with a short education. In this study we estimate a hedonic model of consumer's valuation of food characteristics that allows nutrients to influence utility both through their perceived effects on health and their effects on the taste of food. The model is estimated using purchase data from a consumer panel with comprehensive coverage of food purchases for 2500 Danish households. We find that it is differences in taste valuations, rather than differences in valuation of health effects, that explains the observed differences in dietary healthiness across consumers with different educational backgrounds. .

1. Introduction and background

Unhealthy diet composition can lead to cancer, cardiovascular disease, diabetes, and osteoporosis as well as overweight and obesity (WHO, 2003). This problem is growing dramatically in many modern societies (OECD Health Data, 2011) and a broad range of policies aimed at influencing household food consumption have been introduced or are being considered by policymakers. These include policies like differentiation of food taxes, subsidization of healthy foods, information campaigns and labeling schemes aimed at consumers, and various rules and regulations aimed at firms producing and marketing food products. If we are to understand why diet related problems are growing and how different policies affect consumer behavior it seems obvious that we must have a

sound understanding of why consumers choose to compose their diet as they do. In modern societies it seems that the pleasures of taste and consumption experience often encourage the consumption of fatty, salty and sweet foods, whereas health awareness discourages consumption of the same foods. Essentially, there seems to be a tradeoff between the immediate pleasures of taste and gratification associated with a certain dietary composition and the long term health consequences this implies. With the growing awareness of health related issues among consumers one pressing question is if and how this tradeoff between taste and health affects consumers' valuations of and their demand for different food products. Generally a social bias is observed both in average life expectancy and health behavior. Short educated and low income households live shorter than higher educated higher income households (Sørensen and Brønnum-Hansen, 2006; Ekholm and Zimmerman, 2006; Wamala et al, 1997). These differences are to a large extent caused by differences in health behavior as shorter educated lower income households smoke more, exercise less and have a larger intake of unhealthy nutrients as e.g. saturated fat and sugar. (Eriksen, 2006; Juel, 2008; Groth et al., 2001; Johansen et al., 1999; Calnan, 1990; Dynensen et al, 2003). One possible explanation of the correlation between education and diet healthiness (suggested in numerous papers) is that consumers with a longer education are better at understanding and appreciating the health implication of their diet. If this were the case information campaigns designed for and focusing on increasing health awareness among consumers with a short education might be effective.   However, another possible explanation could be differences in the valuation of the taste effects of e.g. saturated fat or sugar in different foods. If consumers choose an unhealthy diet not because they do not care about the health effects but rather because they have strong taste preferences for unhealthy foods, then information campaign focusing on health awareness might not be effective. In the following we investigate this and find that it is differences in taste valuations, rather than differences in valuation of health effects, that explains the observed differences in dietary healthiness across consumers with different educational backgrounds

Hedonic price models have been widely used to assess consumer valuations of the different attributes inherent in a purchased good. The hedonic price function originates from the characteristic model in which consumers are assumed to derive utility or satisfaction from the characteristics that goods contain rather than from the good itself (Becker, 1965; Lancaster, 1966; Rosen, 1974; Lucas, 1975, Ladd and Suvannunt, 1976). A key implication of this model is that the price paid by a consumer for a purchased good must equal the sum of his marginal valuations of all

the characteristics contained in this product. Based on this, hedonic pricing models have been used to decompose revealed consumer preferences for specific foods into implied valuations of the different characteristics contained in these foods. Examples include tomatoes (Bierlen and Grunewald, 1995; Huang and Lin, 2007), apples (Tronstad et al., 1992), milk (Gillmeister et al., 1996; Lenz et al., 1994), breakfast cereals (Shi and Price, 1998; Stanley and Tschirhart, 1991; Thunström, 2007) through beef or other meat products (Brester et al., 1993, Unnevehr and Bard, 1993, Ladd and Suvannunt, 1976), fish (McConnell and Strand, 2000) and to a minor extend to estimate consumers valuation of more subjective characteristics like variety (Dreicher et al., 2008). Most of these studies consider only a few related food items simultaneously and estimated valuations of nutrients (like for example fat or sugar) contained in different foods differ substantially. This is not surprising since these nutrients in addition to having health implications in many cases also have important effects on the taste experience of consuming the food. If a given nutrients' effect on taste varies between goods, so will its total marginal utility values. However, to the best of our knowledge no studies have attempted to decompose consumer valuations of different nutrients into a marginal valuation that originates from its health effects and a marginal valuation that originates from its taste effect. This is our point of departure.

In our study we utilize a unique panel data set covering *all* components of each households diet (including meat, fish, fruits and vegetables etc.) combined with a long time dimension. This allows us to disentangle taste and health values of a given nutrient under the key identifying assumptions that the health value of a given nutrient in a consumer's diet depends on his total consumption of this nutrient while the taste value of consuming this nutrient in a given food only depends on his consumption of the nutrient contained *in the given type of food*. More specifically we model health and taste valuations of (saturated fat, sugar, carbohydrates, fibers and protein) contained in eight aggregate foods (Meat, Dairy, Bread, flour and cereals, Fish, Convenience foods, Fruit and vegetables, Fats, Biscuits, cakes, spreadables, and icecream).[1]

The rest of this paper is organized as follows: section 2 gives the theoretical model, section 3 the empirical model and identification, section 4 is devoted to a description of the data. Section 5 shows the results while section 6 discusses and concludes.

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[1] For a description of how the groups are composed see appendix A

2. A theory model of food demand

In the classical characteristics model utility is derived directly from consumption of characteristics such as taste or nutrients inherent in the food that the consumer consumes. This implies that a given nutrient in one food is a perfect substitute for the same nutrient contained in another food – or in other words the consumer does not care if the extra pound of fat he is to consume is contained in his milk or in his spare ribs. This assumption does not seem unreasonable when studying a small group of similar goods (like different milk variants or different breakfast cereals) as is typically the case in this literature. However, our endeavour is to model consumer choice covering the entire food basket and then the assumption may be problematic. While assuming that the utility value of decreasing the content of fat in the diet for health reasons is the same irrespective of which food it is contained in may be reasonable, it seems obvious that the corresponding implications for taste and consumption experience can vary substantially between different foods (like milk and spareribs). In the following we therefor model the nutrients' effect on these two different parts of the consumer's utility explicitly, which allows us to apply more reasonable assumptions in both cases.

We consider a household consuming a vector of J (running index j) different foods. Following the traditional characteristics model approach (e.g. used by Ladd and Zober (1977), Lenz et al. (1994), Shi and Price (1998) and Ranney and McNamara (2002)) we assume that each food consists of a number of nutritional characteristics and a number of non-nutritional characteristics.

The amount of nutrient i contained in one unit of good j is given by a technology matrix $\mathbf{A}$:

(1)
$$A \equiv goods \begin{cases} 1 \\ \vdots \\ j \\ \vdots \\ J \end{cases} \overbrace{\begin{pmatrix} a_{11} & \cdots & a_{1i} & \cdots & a_{1I} \\ \vdots & \ddots & \vdots & \iddots & \vdots \\ a_{j1} & \cdots & a_{ji} & \cdots & a_{jI}! \\ \vdots & \iddots & \vdots & \ddots & \vdots \\ a_{J1} & \cdots & a_{Ji} & \cdots & a_{JI} \end{pmatrix}}^{Health-characteristics}$$
with column headers $1 \quad \ldots \quad i \quad \ldots \quad I$

In the same way the amount of non-nutrient characteristic m contained in one unit of good j is given by a similar technology matrix $\mathbf{B}$.

If we assume that the consumer consumes one type of each good (the types characterised by containing the characteristics implied by technology matrices $\mathbf{A}$ and $\mathbf{B}$) then the total amount of

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nutritional characteristics (given by vector $\mathbf{h}$ of I nutritional characteristics $\mathbf{h} = (h_1,...h_i,...h_I)$)
consumed by the household is:

(2) $$\mathbf{h} = \mathbf{A'q}$$

Where $\mathbf{q} = (q_1,...q_i,...q_J)$ is a vector of quantities of consumed foods. While the total amount of
non-nutritional characteristics consumed (given by vector $\mathbf{g}$ of M non-nutritional characteristics
$\mathbf{g} = (g_1,...g_m,...g_M)$) is:

(3) $$\mathbf{g} = \mathbf{B'q}$$

When a household purchases a vector of foods it is assumed to derive taste utility from consuming
the vector of foods. Taste utility is assumed to be produced in a two-step process: first in the lower
nest characteristics contained in each food j is combined to produce taste sub-utility for this food:

(4) $$x_j = k_j\left(\mathbf{h}_j,\mathbf{g}_j\right)$$

where $\mathbf{h}_j = \mathbf{a}_j q_j$ is the vector of quantities of nutrients consumed in good j ($\mathbf{a}_j$ is the relevant vector
of per unit nutrient characteristics from the technology matrix A i.e. the content of saturated fat,
sugar etc. in good j). In the same way $\mathbf{g}_j = \mathbf{b}_j q_j$ is the vector of non-nutritional characteristics
consumed in good j. We will assume homogeneity of taste production so that $x_j = q_j k_j\left(\mathbf{a}_j,\mathbf{b}_j\right)$
which allows us to interpret $k_j\left(\mathbf{a}_j,\mathbf{b}_j\right)$ as a quality measure for good j[2]. Essentially the taste quality
of a unit of good j depends on its content of characteristics. For example a pound of beef may have
a higher taste quality when it contains 20% fat then when it contains 10% or 30% fat and this
valuation is not affected by the amount of beef consumed. This seems a natural and intuitive
interpretation.

In the second step utility is produces by combining the good specific taste sub-utilities derived from
each good:

(5) $$u\left(x_1,,x_J\right)$$

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[2] Note that this model is synonymous with a characteristics model of taste production from aggregate goods when
homogeneity of sub-utility production is assumed see e.g. Lenz et al. (1994). The difference to Lenz and others is that
we allow nutritional characteristics to influence taste.

This is a traditional model of consumption where (as we have formulated it) the quality of each good is a function of the different characteristics contained in it.

When a household purchases a vector of foods it is, in addition to the taste utility this gives, assumed to derive health utility depending on the total amount of each nutritional characteristics contained in its diet h_i:

(6) $$v_i(h_i)$$

We assume that the consumers' total utility is the sum of utility derived from taste, the utility derived from different health characteristics plus the utility derived from expenditures on a numeraire good representing consumption of non-food goods. Expenditure on the numeraire is equal to income Y minus expenditures on the J different foods $\sum_{j=1}^{J} X_j$ so that the consumer's utility becomes:

(7) $$U = u(x_1,,x_J) + \sum_{i=1}^{I} v_i(h_i) + Y - \sum_{j=1}^{J} X_j$$

Thus we assume additive separability of utility from health, from taste and from consuming other goods.

Consumer behaviour

We assume that each of the *J* goods can be bought in different qualities on the market, depending on the per unit characteristics contained in them. Given the prices of different qualities on the market $p_j(a_j, b_j)$ the consumer chooses both quantity and quality of each good so as to maximize normalized utility:

(8)
$$\underset{q, \mathbf{A}, \mathbf{B}}{Max} U = u(x_1,...,x_J) + \sum_{i=1}^{I} v_i(h_i) + Y - \sum_{j=1}^{J} p_j(\mathbf{a_j}, \mathbf{b_j}) q_j$$
$$S.T \quad x_j = k_j(\mathbf{h}_j, \mathbf{g}_j)$$

For ease of exposition we have constrained the consumer to choose only one quality of each good. It is however, easy to show that the optimal solution always implies this, since different qualities of

a given good are perfect substitutes[3]. The resulting first order condition for optimal choice of quality and quantity of good j (the hedonic pricing equation) is:

$$
\begin{aligned}
p_j(\mathbf{a}_j, \mathbf{b}_j) &= \sum_{m=1}^{M} \frac{dU}{dg_{jm}} b_{ji} + \sum_{i=1}^{I} \frac{dU}{dh_{ji}} a_{ji} \\
&= u'_j \left(\sum_{m=1}^{M} \frac{dk_j(\mathbf{h}_j, \mathbf{g}_j)}{dg_{jm}} b_{ji} + \sum_{i=1}^{I} \frac{dk_j(\mathbf{h}_j, \mathbf{g}_j)}{dh_{ji}} a_{ji} \right) + \sum_{i=1}^{I} v'_i(h_j) a_{ji}
\end{aligned}
$$

(9)

Thus the marginal utility value of taste derived from good j in general depends on consumption of other goods in a complicated way (marginal taste values of goods depend on the consumption of other goods: $u'_j(x_1,..x_J)$). Nevertheless, the marginal health utility value of nutrients only depends on the aggregate consumption of this nutrient because of the assumed separability structure. Further the separability implied by our model of taste quality implies that the taste quality function only depends on the characteristics contained in the specific good. [4] This is what allows us identification in the empirical model.

3. Empirical specification and identification

Multiplying (9) by q_j we get:

(10)
$$
X_j = u'_j \left(\sum_{m=1}^{M} \frac{dk_j(\mathbf{h}_j, \mathbf{g}_j)}{dg_{jm}} g_{ji} + \sum_{i=1}^{I} \frac{dk_j(\mathbf{h}_j, \mathbf{g}_j)}{dh_{ji}} h_{ji} \right) + \sum_{i=1}^{I} v'_i(h_j) h_{ji}
$$

Where X_j is expenditure on good j and h_{ji} is the total amount of nutrient i in the specific good. This is the first order condition that we will estimate empirically. We assume taste quality is linear in non-nutritional characteristics i.e.

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[3] When different qualities of the same good are perfect substitutes, then it is optimal to consume the quality that to the given market prices gives the consumer the largest amount of quality adjusted units per monetary unit:

$(k_j(\mathbf{a}_j, \mathbf{b}_j) + \sum_{i=1}^{I} v'_i(h_i) a_{ji}) / p_j(\mathbf{a}_j, \mathbf{b}_j)$. Note again that this is synonymous with the aggregate good model

assuming homogeneity of sub-utility production (see e.g. Lenz et all 1994). To see this just let different qualities be defined as aggregate goods differing in their composition of the same set of underlying goods. Under homogeneity optimal aggregate good composition is independent of the consumed quantity of the aggregate good.

[4] One could imagine non separable relationships where one quality of a certain food tastes especially well with specific qualities of other foods (sweet wine with sweet desserts etc). These are the types of complex substitutional relationships that we have ruled out.

(11)
$$\frac{dk_j\left(\mathbf{h}_j, \mathbf{g}_j\right)}{dg_{jm}} = \delta_{jm}$$

These are proportions of meat or vegetable types with a clear preference ranking (e.g. greater proportion roast beef might imply greater quality). For the nutritional characteristics we allow quadratic form allowing for e.g. top quality beef of a certain fat content will have falling quality both with lower and higher per unit contents so that:

(12)
$$\frac{dk_j\left(\mathbf{h}_j, \mathbf{g}_j\right)}{dh_{ji}} = \alpha_{ji} + \beta_{ji}\left[h_{ji} / q_j\right]$$

where the marginal value depends on the per unit content (concentration) of the nutrient. Note that this satisfies the assumed homogeneity of taste. Finally we allow the same quadratic form for health utility of nutrients:

(13)
$$v'_i\left(h_i\right) = \gamma_i + \varepsilon_i\left[h_i\right]$$

We allow u'_j to vary over time ,to take account of the vector of consumed food goods changing over time – but because of the assumed separability quality and health utility parameters are constant over time. Technically we do this by including time and good specific dummies $u'_j(t)$ for each representative household that we model so that the regression equations that we estimate becomes:

(14) $$\left[X_j\right] = u'_j(t)\left(\sum_{m=1}^{M}\delta_{jm}\left[g_{jm}\right] + \sum_{i=1}^{I}\alpha_{ji}\left[h_{ji}\right] + \sum_{i=1}^{I}\beta_{ji}\left[h_{ji}^2 / q_j\right]\right) + \sum_{i=1}^{I}\left(\gamma_i\left[h_{ji}\right] + \varepsilon_i\left[h_i h_{ji}\right]\right)$$

for each good *j*. Where square brackets indicate observed variables in our data set and *t* indicates time. For each food the first non-nutritional characteristic is q_j capturing unobserved characteristics contained in this food.

We see that second order taste and health effects of nutrients (β_{ji} and ε_i respectively) in (14) are identified through our assumptions about their dependence on nutrients contained in the given food and the total amount of consumed nutrients respectively. The separation of first order taste and

health effects (α_{ji} and γ_i) is on the other hand only through our assumption that taste effects vary over time and between foods while health effects do not.

4. Data and model structure

In the present paper we use weekly self- reported purchase data from a Danish consumer panel maintained by GfK-Denmark.[5] The panel contains on average 2500 households reporting quantity, price and detailed product characteristics of (in principal) all their food purchases. We aggregate to monthly observations, covering the entire year of 2004 as well as a number of background variables characterising each household (collected using a mail survey). The diary is filled in by the diary keeper in principle immediately after each shopping and is sent to GfK on a weekly basis. The level of detail in the purchase is for many foods close to barcode level. The purchase data are concatenated with nutrition matrices from the Food Composition Databank provided by the Danish Institute for Food and Veterinary research.[6] The nutrition data base provides detailed information about the content of macronutrients (as e.g. protein, fats, carbohydrates and fibres in 1032 different foods).[7] As all values are given per 100 g edible part in the nutrient matrices, it is possible to calculate the total amount of various macronutrients purchased by the households by concatenating the nutrition matrices with the purchase data. For each type of food the match is done on the most detail level possible. It is for example possible to separate the purchased quantity of milk into different types of milk (e.g. butter milk, whole milk, semi skimmed milk, skimmed milk and flavoured milk) and to match each type with a nutrition matrix describing the exact content of nutrients in this particular type of milk.[8] This results in a panel dataset at household level where the nutritional composition of purchases are measured together with prices and expenditure.

We follow the approach in Lenz et al, 1994 and construct 32 aggregate food "qualities" which each consists of a number of underlying sub-qualities of the particular quality.[9] Prices and technology matrices are then constructed as average values from these *k* market goods:

Not all goods contain all types of nutrients. Table 1 shows the amount of each of the five nutrients in grams per kilo in each of the *j* food categories (e.g. there is on average 56.48 grams of protein in one kilogram of dairy products while there is on average 2.59 grams of added sugar).

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[5] Data are provided by GfK Denmark., For a throughout description of the data see Smed (2008)

[6] (http://www.foodcomp.dk/fcdb_default.asp)

[7] The database covered 1032 different foods in 2005, but is continuously improved

[8] For a detailed description of the concatenation of purchase data with the nutrition matrices see Smed (2008)

[9] The 32 goods are shown in appendix A

Table 1: Content of nutrients in each of the food categories (g/kg)

	Dairy	Meat	Fats	Fruits and vegetables	Biscuits, cakes, spreadables and icecreame	Fish	Flour, bread and cereals	Convenience
Protein(g/kg)	56.48	212.81	2.76	12.03	31.53	149.95	64.00	44.45
Carbohydrates (g/kg)	46.18	10.70	2.84	90.92	448.31	63.50	480.80	285.04
Fibre (g/kg)	0.22	0.60	0.00	19.41	8.51	0.62	33.90	17.19
Added sugar (g/kg)	2.59	1.48	0.00	0.00	278.84	0.00	3.79	5.74
Saturated fat (g/kg)	25.25	63.22	314.78	0.73	29.01	16.78	3.81	11.70

Table 2 shows the percentage contribution to the total consumption of each of the five nutrients from each of the eight food categories (e.g. dairy products contributes with 19.65 per cent of total consumption of saturated fat while meat contribute with only 30 per cent). The latter table is partly used to choose the variables in the model together with a more subjective valuation of whether this particular nutrient has a significant influence on the taste experience of this food. When a food category is a large contributor to the aggregate consumption of the nutrient in question consumption of this nutrient from this particular food group is a variable in the model. Variables included in the model are shaded while un-shaded interactions are excluded.

Table 2: The contribution from each food category to total nutrient consumption (% of total consumption)

	Dairy	Meat	Fats	Fruits and vegetables	Biscuits, cakes, spreadables and icecreame	Fish	Flour, bread and cereals	Convenience	
Protein(g/kg)	17.35%	40.24%	0.10%	3.71%	4.71%	11.95%	17.80%	4.14%	100%
Carbohydrates (g/kg)	5.13%	0.73%	0.04%	10.14%	24.20%	1.83%	48.34%	9.59%	100%
Fibre (g/kg)	0.36%	0.61%	0.00%	32.35%	6.86%	0.27%	50.91%	8.64%	100%
Added sugar (g/kg)	1.80%	0.63%	0.00%	0.00%	93.99%	0.00%	2.38%	1.21%	100%
Saturated fat (g/kg)	19.65%	30.28%	29.69%	0.57%	10.98%	3.39%	2.68%	2.76%	100%

5. Estimation

The model is estimated as a system of eight simultaneous equations using the NLSUR command in STATA 10. As the model is highly non-linear it is not straight forward to use standard panel data methods to account for unobserved heterogeneity. The model is estimated independently for three

different educational groups, short education (no or vocational education), medium (short non-vocational education) and long education (medium or long non-vocational education).

Table 3: Results from FGNLS regression

Equation	Obs	No. Parms	RMSE	R-sq
Overall model				
Total expenditure on fish	22407	21	29.00716	0.9797*
Total expenditure on dairy	22407	23	91.92737	0.9143*
Total expenditure on fats	22407	30	45.27036	0.9661*
Total expenditure on convenience	22407	29	13.17212	0.9609*
Total expenditure on fruits and vegetables	22407	17	20.49735	0.9097*
Total expenditure on flour, bread and cereals	22407	39	58.73261	0.9362*
Total expenditure on meat	22407	26	158.8067	0.9193*
Total expenditure on Biscuits, cakes, spreads and icecream	22407	34	41.46863	0.9285*
Short education				
Total expenditure on fish	13612	21	30.21305	0.9790*
Total expenditure on dairy	13612	23	77.73719	0.9258*
Total expenditure on fats	13612	30	39.76351	0.9711*
Total expenditure on convenience	13612	29	13.02174	0.9623*
Total expenditure on fruits and vegetables	13612	17	20.82811	0.9134*
Total expenditure on flour, bread and cereals	13612	39	57.14703	0.9372*
Total expenditure on meat	13612	26	150.0569	0.9255*
Total expenditure on Biscuits, cakes, spreads and icecream	13612	34	39.49291	0.9341*
Medium education				
Total expenditure on fish	3091	21	26.6629	0.9827*
Total expenditure on dairy	3091	23	103.4018	0.9047*
Total expenditure on fats	3091	30	44.45371	0.9677*
Total expenditure on convenience	3091	29	12.66126	0.9629*
Total expenditure on fruits and vegetables	3091	17	20.26286	0.9041*
Total expenditure on flour, bread and cereals	3091	39	57.80031	0.9407*
Total expenditure on meat	3091	26	158.3078	0.9230*
Total expenditure on Biscuits, cakes, spreads and icecream	3091	34	41.20668	0.9256*
Long education				
Total expenditure on fish	4320	21	27.16199	0.9802*
Total expenditure on dairy	4320	23	114.4946	0.9089*
Total expenditure on fats	4320	30	54.63627	0.9622*
Total expenditure on convenience	4320	29	12.86821	0.9597*
Total expenditure on fruits and vegetables	4320	17	19.57799	0.9049*
Total expenditure on flour, bread and cereals	4320	39	57.43009	0.9422*
Total expenditure on meat	4320	26	167.2968	0.9137*
Total expenditure on Biscuits, cakes, spreads and icecream	4320	34	44.53179	0.9207*

* Uncentered R-square

The parameter values for the non-nutritional attributes are shown in appendix B; parameter values for the health and taste attributes of nutrients are shown in table 4 below.

Table 4: Parameter values - health

	Nutrient i	Average		Short education		Medium education		Long education	
		Coef	P>z	Coef	P>z	Coef	P>z	Coef	P>z
Common health parameter γ_i	Carbohydrates	-0.0068	0.0000	-0.0081	0.0000	-0.0128	0.0020	0.0123	0.0000
	Fibers	0.5023	0.0000	0.5162	0.0000	0.4971	0.0000	0.1809	0.0000
	Saturated fat	0.1176	0.0000	0.1148	0.0000	0.0873	0.0000	0.1687	0.0000
	Sugar	0.0198	0.0000	0.0223	0.0000	0.0303	0.0000	0.0035	0.5310
	Protein	0.1648	0.0000	0.1612	0.0000	0.1847	0.0000	0.1457	0.0000
Common health parameter, quadratic ε_{ij}	Carbohydrates	-5.20E-08	0.0000	-5.01E-08	0.0000	-6.79E-08	0.0000	-9.91E-08	0.0000
	Fibers	2.46E-06	0.0010	1.38E-06	0.1130	2.79E-06	0.2190	1.28E-05	0.0000
	Saturated fat	-2.51E-06	0.0000	-2.35E-06	0.0000	-2.89E-06	0.0000	-2.80E-06	0.0000
	Sugar	-1.84E-06	0.7870	-8.18E-07	0.0000	-1.37E-06	0.9740	-6.15E-07	0.0000
	Protein	-3.36E-07	0.0000	-2.84E-07	0.0000	-4.35E-07	0.0000	-7.21E-07	0.0000

Below are the averaged parameter values for the taste of nutrient shown. The parameter values for

Table 5: Parameter values - taste, α_{ij} and β_{ij} for educational groups[10]

Nutrient i	Good j	Short education		Medium education		Long education	
		Coef.	P>z.	Coef.	P>z.	Coef.	P>z.
Carbohydrates α_{ij}	Flour, bread etc.	-0.0195	0.0020	-0.0397	0.0040	-0.0267	0.0130
	Fruits and vegetables	0.1060	0.0000	0.1809	0.0000	0.1306	0.0000
	Convenience	-0.0015	0.6580	-0.0019	0.8130	-0.0075	0.2040
	Biscuits, cakes etc.	0.0109	0.0000	0.0328	0.0000	-0.0029	0.5390
Carbohydrates Squared β_{ij}	Flour, bread etc.	0.0001	0.0060	0.0002	0.0240	0.0001	0.4640
	Fruits and vegetables	-0.0053	0.0000	-0.0089	0.0000	-0.0068	0.0000
	Convenience	0.0003	0.0000	0.0003	0.0120	0.0001	0.2830
	Biscuits, cakes etc.	0.0001	0.0000	0.0000	0.7690	0.0000	0.2440
Fibre α_{ij}	Flour, bread etc.	-0.5935	0.0000	-0.5919	0.0000	-0.1233	0.0230
	Fruits and vegetables	0.1268	0.0000	-0.1526	0.0730	0.3745	0.0000
	Convenience	-0.1780	0.0000	0.6422	0.0000	0.6634	0.0000
Fibre Squared β_{ij}	Flour, bread etc.	0.0017	0.2400	0.0048	0.1660	-0.0112	0.0000
	Fruits and vegetables	-0.1252	0.0000	-0.0549	0.0040	-0.1706	0.0000
	Convenience	-0.0863	0.0000	-0.2192	0.0000	-0.1939	0.0000
Protein	Flour, bread etc.	-0.1281	0.0000	0.0331	0.6730	-0.1853	0.0040

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[10] Parameter values for the non-nutritional taste parameters are shown in appendix B

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α_{ij}	Dairy	-0.0942	0.0030	-0.1985	0.0000	-0.1305	0.0300
	Fish	0.2869	0.0000	0.3991	0.0000	0.4553	0.0000
	Meat	-0.1435	0.0000	-0.1367	0.0000	-0.0966	0.0000
	Convenience	-0.2447	0.0000	-0.4564	0.0000	-0.3739	0.0000
	Biscuits, cakes etc.	0.0867	0.0000	-0.0104	0.7720	0.0697	0.0250
Protein Squared β_{ij}	Fish	-0.0207	0.0000	-0.0028	0.6170	-0.0079	0.0570
	Flour, bread etc.	-0.0001	0.0000	-0.0002	0.0000	0.0000	0.4890
	Dairy	-0.0050	0.0190	-0.0019	0.7070	0.0034	0.4080
	Meat	-0.0141	0.0000	-0.0191	0.0000	-0.0198	0.0000
	Convenience	-0.0119	0.0000	-0.0199	0.0000	-0.0158	0.0000
	Biscuits, cakes etc.	-0.0028	0.0050	-0.0063	0.0000	0.0015	0.5190
Saturated fat α_{ij}	Flour, bread etc.	-0.0225	0.1900	-0.1867	0.0010	-0.1974	0.0000
	Dairy	-0.1014	0.0000	-0.1022	0.0000	-0.1176	0.0000
	Fats	0.0258	0.0000	0.0903	0.0000	0.0105	0.0770
	Fish	0.2528	0.0000	0.0125	0.8660	0.1563	0.0220
	Meat	-0.1941	0.0000	-0.2119	0.0000	-0.2358	0.0000
	Convenience	0.0493	0.0000	0.0291	0.2490	-0.1971	0.0000
	Biscuits, cakes etc.	-0.0323	0.0000	0.0456	0.0000	-0.0323	0.0080
Saturated fat squared β_{ij}	Fish	-0.0073	0.1780	0.0498	0.0300	0.0073	0.2430
	Flour, bread etc.	0.0076	0.0000	0.0039	0.0600	0.0035	0.3610
	Dairy	-0.0019	0.0000	-0.0019	0.0000	-0.0017	0.0000
	Fats	-0.1753	0.0000	-0.1314	0.0000	-0.1847	0.0000
	Meat	0.0013	0.0000	0.0032	0.0000	0.0018	0.0000
	Convenience	0.0067	0.0010	0.0240	0.0000	0.0450	0.0000
	Biscuits, cakes etc.	-0.0022	0.0000	-0.0061	0.0000	-0.0083	0.0000
Sugar α_{ij}	Flour, bread etc.	0.0632	0.0000	0.0816	0.0000	0.0680	0.0000
	Dairy	0.2237	0.0000	0.4681	0.0000	-0.0024	0.9680
	Biscuits, cakes etc.	-0.0093	0.0040	-0.0332	0.0000	0.0064	0.3580
Sugar Squared β_{ij}	Flour, bread etc.	-0.0095	0.0000	-0.0067	0.0020	-0.0089	0.0020
	Dairy	0.0022	0.8000	-0.0587	0.0000	-0.0207	0.2600
	Biscuits, cakes etc.	-0.0001	0.0000	0.0000	0.4600	-0.0001	0.0740

6. Results

6.1 Average marginal valuation of the health effects of nutrient consumption

To interpret the parameter values we calculate the marginal valuation of health for the average consumer as a function of the total amount of nutrients consumed as:

(15) $Marginal\,Valutation_{health,ij} = \gamma_i + \varepsilon_{ij}[h_i]$

In figure 1 below the estimated health valuations for different nutrients are illustrated graphically as a function of the total consumption of the nutrient.

Figure 1: Marginal health valuation of nutrients
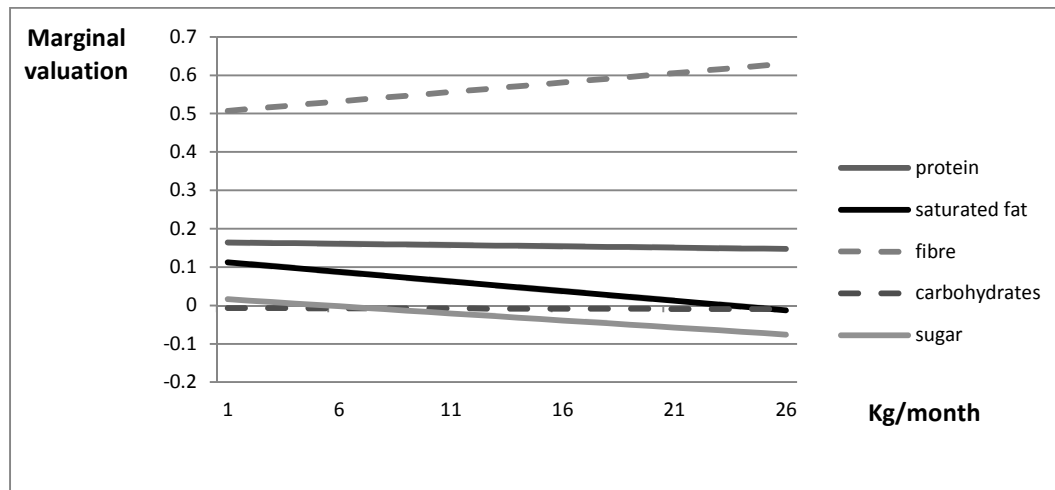
The marginal valuations of the health effects of sugar and saturated fat consumption are declining, and more so for sugar than for saturated fat. This is in line with the official Danish diet recommendations that recommend a diet with no more than 10 per cent of total energy to originate from sugar and no more than 10 per cent from the consumption of saturated fat. Focus has in many years been mainly on the detrimental effects of consumption of saturated fat, which has increased consumer awareness (Holm et al, 2002), but in recent year the focus on the detrimental effects of sugar consumption has intensified with especially several campaigns targeted adolescents. [11] Therefor it seems reasonable that the marginal valuation of the health effects of sugar consumption is more negative than for saturated fat consumption as this might be more recent in consumers' minds. The official recommendations for fiber intake are a minimum of 3 g per MJ, equal to approximately 2.4 per cent of total energy intake which is in line with the positive and increasing marginal valuation of the health effect of fiber consumption observed in figure 1. There are no official recommendations concerning intake of protein, and the recommendations concerning the intake of carbohydrates are mixed. The old recommendations encouraged an intake of at least 60 per cent of total energy intake from carbohydrates, but the new revised recommendations divide carbohydrates into "slow" and "fast" carbohydrates. They recommend a limited consumption of carbohydrates from white bread, pasta and rice (fast carbohydrates), but unlimited intake of

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[11] http://www.maksenhalvliter.dk/Services/omkampagnen/omkampagnen.htm

carbohydrates from brown bread and other wholegrain products (slow carbohydrates). This is in line with the results from figure 1, with a positive, but low marginal valuation of the health effects from protein consumption and around zero marginal valuation of the health effects from carbohydrate consumption.

6.2 Socio-demographic differences

We know from prior research that individuals with a longer education eat healthier than individuals with shorter education (Smed, 2008; Eriksen, 2006; Juel, 2008; Groth et al., 2001; Johansen et al., 1999; Calnan, 1990; Dynensen et al, 2003). Thus all in all consumers with a short education value healthy foods less and unhealthy foods more than consumers with a long education. Our focus is on investigating if this difference is driven by different valuations of health effects of nutrients or by differences in valuations of taste effects focusing on the consumption of sugar and saturated fat. Figure 2 below shows the marginal valuation of the health effect from consumption of saturated fat as a function of total nutrient consumption (calculated using equation 15 as in figure 1 above) for saturated fat.

Figure 2: Marginal valuation of the health effects of saturated fat consumption for educational groups
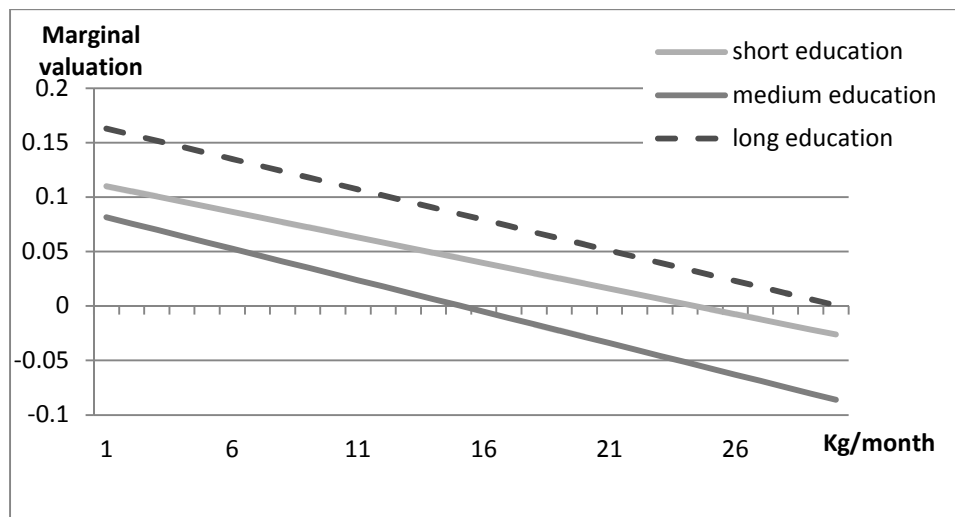
In each figure we present marginal valuation curves for households where the main shopper has a short, medium and long education. We see that all three consumer types find that high levels of consumption are associated with negative health effects. However, surprisingly we find that medium educated consumers are the most concerned about health effects from saturated fat (they have the lowest health valuation curve for saturated fat), whereas consumers with a long education

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are the *least* concerned. This implies that differences in health concerns *cannot* explain the lower level of consumption of saturated fat among consumers with a longer education - on the contrary. In figure 3 we see the corresponding taste valuation curves for fat in dairy products, meat and in biscuits, cakes, spreads and ice-cream. The range on the x-axis runs from the 10th to the 90th percentile of the distribution of the possible contents of saturated fat in good *j*. We see that consumers with a short education do appreciate the taste of fat in dairy products and biscuits, cakes, spreads and ice-cream substantially more than consumers with a high education while there is no difference for fat in meat. Thus the higher consumption of fat among less educated consumers is explained by greater preferences for the taste of fat in a dairy products and biscuits, cakes, spreads and ice-cream, not by these consumers being less concerned about health effects. The same is true for the medium educated consumers. Their higher consumption of fat is driven by preferences for the taste of fat in meat. In fact both the short and medium educated groups are more concerned about health effects of fat then are consumers with a high education even though observed consumption is higher

Figure 3: Taste valuation of taste effect of saturated fat in different foods for different educational groups
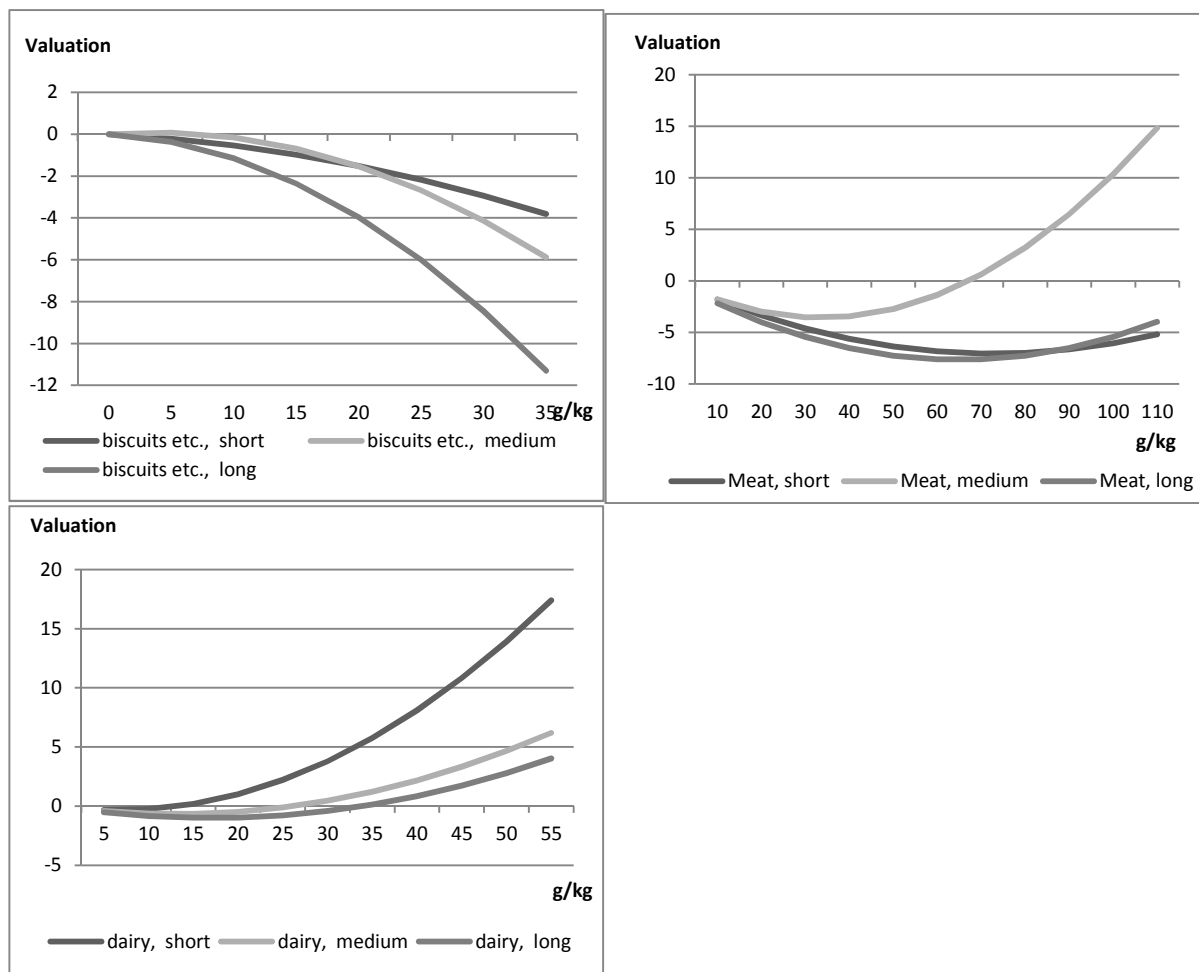
Figure 4 below shows the marginal valuation of the health effect from consumption of saturated fat as a function of total nutrient consumption (calculated using equation 15 as in figure 1 above) for saturated fat. In each figure we present marginal valuation curves for households where the main shopper has a short, medium and long education.

Figure 4: Marginal health valuation of sugar for educational groups
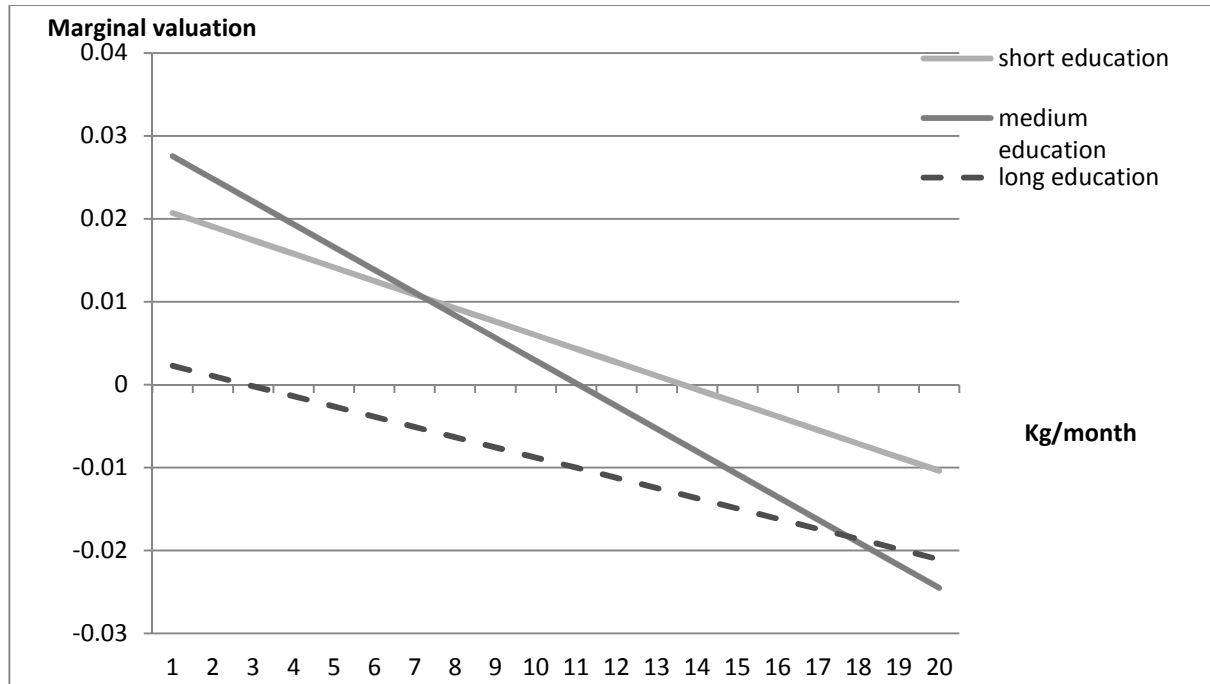

Looking at the figure 4 we see that health concerns about sugar do follow the expectation that consumers with a short education generally have a larger consumption of sugar than high educated. The long educated find the health effects of sugar consumption very negative whereas medium and short educated does not consider sugar consumption has unhealthy as the longer educated.

In figure 5 we see the corresponding taste valuation curves for sugar in dairy products as well as biscuits, cakes, spreads and ice-cream. The range on the x-axis runs from the 10th to the 90th percentile of the distribution of the possible contents of sugar in good *j*. The valuations of the taste effect of sugar in dairy products are highly negative for long educated and almost entirely positive for the short educated. Concerning biscuits, cakes, spreads and ice-cream products all types of household have a negative valuation of the taste of sugar with medium educated being most negative and long educated the least negative, but if we take into account that the monthly

consumption of dairy products in kilo grams per household are almost three times as large as the consumption of biscuits, cakes, spreads and ice-cream this might still be in correspondence with observed actual consumption of sugar.

Figure 5: Taste valuation of taste effect of sugar in different foods for different educational groups
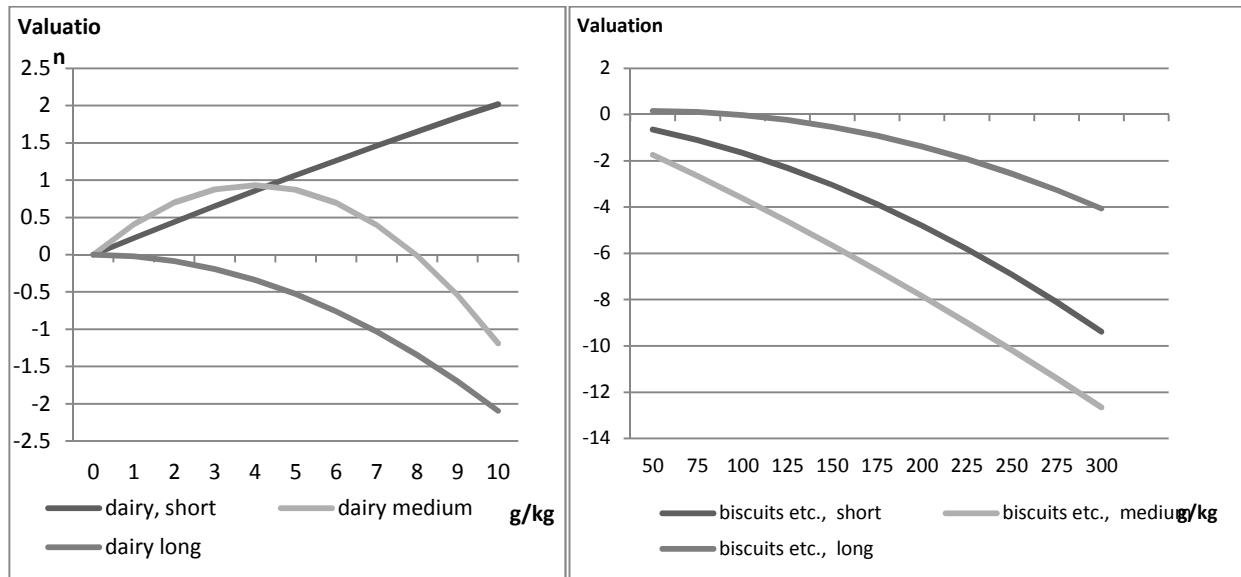
7. Discussion and conclusion

Most hedonic studies model only a few related food-items simultaneously and when comparing estimated valuations of nutrients (like for example fat or sugar) contained in different foods from these studies they are found to differ substantially. This is not surprising since these nutrients in addition to having health implications in many cases also have important effects on the taste experience of consuming the food. If a given nutrients' effect on taste varies between goods, so will its total marginal utility values. In this paper we develop a hedonic model, based on the repackaging model of quality which consistently makes it possible to disentangle taste and health values of a given nutrient under the key identifying assumptions that the health value of a given nutrient in a consumer's diet depends on his total consumption of this nutrient, while the taste value of consuming this nutrient in a given food only depends on his consumption of the nutrient contained in the given type of food. The results in this paper points towards that the different consumer types division of the utility value of nutrients in foods into health and taste values respectively could have important implications for how consumers react to different policies and hereby how we could be able to change consumer behavior regarding diets. To the extent that consumer consumption of detrimental nutrients are guided mainly by a preference for the taste effect that these nutrients have

on the consumed food and, not health considerations, information campaigns with the aim of decreasing consumption of these nutrients will have no or only limited effect. In this case the largest effect will be seen from policies that aim to change consumer taste preferences for different types if food. As taste preferences often are formed in early childhood this might preferably be through e.g. school meals. Other policies where individuals can learn to appreciate the taste of healthy foods might also be effective. If consumers' consumption of detrimental nutrients is guided by health considerations information campaigns and other forms of health education will be the most effective.

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Appendix A: The aggregation of foods into goods

Original grouping in data	Quality variants of good	Good
Processed fish	Processed fish	Fish
Fish	Fish	
Processed meat for bread	Processed meat	Meat
Liver pâté		
Brawn and pâté		
Rissole		
Bacon		
Sausages		
Beef and other meat	Beef	
	Other meat	
Pork	Pork	
Poultry	Poultry	
Eggs	Eggs	
Butter	Butter	Fats
Oil	Oil	
Margarine	Margarine	
Bouillon and soups	Other processed food	Convenience
Sauce		
Salad dressing etc.		
Ketchup		
Pizza	Dishes	
Dishes with rice and pasta		
Chocolate (for bread)	Spreadable	Biscuits, cakes, spreads and ice-cream
Marmalade		
Biscuits	Biscuits	
Ice cream	Ice cream	
Sugar	Sugar	

Cake	Cakes	
Cookies		
Fruit	Fruit	Fruit and vegetables
Vegetables	Vegetables	
Frozen vegetables	Frozen vegetables	
Potatoes	Potatoes	Flour, bread and cereals
Cereals	Cereals	
White bread	White bread	
Brown bread	Brown bread	
Flour	Flour	
Crisp bread	Crisp bread	
Rice	Rice	
Pasta	Pasta	
Speciality cheese	Cheese	Dairy
Ordinary cheese		
Milk	Milk	
Yoghurt	Yoghurt	

Appendix B: Parameter values for nonnutritional characterstics

	Average		Short education		Medium education		Long education	
	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z
Eggs	0.0291	0.0000	0.0276	0.0000	0.0284	0.0000	0.0306	0.0000
Other meat	0.0602	0.0000	0.0623	0.0000	0.0405	0.0000	0.0783	0.0000
Convenience meals	0.0543	0.0000	0.0561	0.0000	0.0491	0.0000	0.0519	0.0000
Fish	0.0329	0.0000	0.0355	0.0000	0.0250	0.0000	0.0259	0.0000
Preserved fish	-0.0066	0.0000	-0.0055	0.0150	-0.0088	0.0260	-0.0116	0.0070
Poultry	0.0250	0.0000	0.0247	0.0000	0.0228	0.0000	0.0233	0.0000
Frozen fruits/vegt	0.0038	0.0000	0.0028	0.0000	0.0009	0.3380	0.0106	0.0000
Fruit	-0.0001	0.0670	0.0001	0.2000	-0.0005	0.0000	-0.0003	0.0290
Vegetables	0.0061	0.0000	0.0043	0.0000	0.0038	0.0000	0.0111	0.0000
Cereals	0.0435	0.0000	0.0410	0.0000	0.0400	0.0000	0.0488	0.0000
White bread	0.0406	0.0000	0.0382	0.0000	0.0426	0.0000	0.0432	0.0000
Cakes	0.0054	0.0000	0.0054	0.0000	0.0028	0.0150	0.0075	0.0000
Potatoes	0.0088	0.0000	0.0090	0.0000	0.0106	0.0000	0.0058	0.0000
Biscuits	0.0064	0.0000	0.0085	0.0000	-0.0024	0.2490	0.0058	0.0020
Crackers	0.0637	0.0000	0.0632	0.0000	0.0683	0.0000	0.0621	0.0000
Milk	0.0082	0.0000	0.0079	0.0000	0.0310	0.0000	0.0046	0.0550
Margarine	-0.0106	0.0000	-0.0077	0.0000	-0.0173	0.0000	-0.0212	0.0000
Flour	0.0306	0.0000	0.0284	0.0000	0.0323	0.0000	0.0303	0.0000
Beef	0.0480	0.0000	0.0483	0.0000	0.0459	0.0000	0.0453	0.0000
Cheese	0.0459	0.0000	0.0368	0.0000	0.0827	0.0000	0.0415	0.0000
Pasta	0.0387	0.0000	0.0364	0.0000	0.0379	0.0000	0.0390	0.0000
Processed food	0.0166	0.0000	0.0170	0.0000	0.0142	0.0000	0.0168	0.0000
Processed meat	0.0610	0.0000	0.0624	0.0000	0.0633	0.0000	0.0541	0.0000
Rize	0.0411	0.0000	0.0382	0.0000	0.0406	0.0000	0.0409	0.0000
Brown bread	0.0280	0.0000	0.0280	0.0000	0.0316	0.0000	0.0257	0.0000
Butter	0.0103	0.0000	0.0148	0.0000	-0.0047	0.0370	-0.0049	0.0090
Pork	0.0162	0.0000	0.0152	0.0000	0.0155	0.0000	0.0172	0.0000
Spread	0.0155	0.0000	0.0143	0.0000	0.0154	0.0000	0.0190	0.0000
Sugar	-0.0056	0.0000	-0.0061	0.0000	-0.0039	0.2810	0.0005	0.8680

Soured milk	0.0128	0.0000	0.0123	0.0000	0.0368	0.0000	0.0092	0.0010
Soured milk with sugar	0.0028	0.0000	0.0027	0.0000	0.0037	0.0000	0.0021	0.0020
Pork	0.0402	0.0000	0.0407	0.0000	0.0379	0.0000	0.0367	0.0000