Consumer valuation of health attributes in food

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Abstract

In modern societies consumers often face a trade-off between health and taste, the latter which encourages consumption of fatty, salty and sweet foods, whereas health awareness discourages consumption of the same food. The resulting diet, often rich in calories, sweeteners and fat constitutes a threat to public health as poor nutrition has been linked to several types of cancer, cardiovascular disease, diabetes, and osteoporosis as well as overweight and obesity.

In this study we use the hedonic model as an outset to model consumer valuation of nutritional and non-nutritional characteristics of food consumption in a consistent way, accounting for that nutrients might influence utility both through health and through taste. This implies that a given nutrient in one food is not a perfect substitute for the same nutrient contained in another food, which is the case in the classical hedonic price model. However, as we model consumer choice covering the entire food basket then this 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 comes from may be reasonable, it seems obvious that the corresponding implications for taste and consumption experience can vary substantially between different foods.. The data that we use to estimate this model cover 2500 household's food consumption over a year.

More specifically the aim of this paper is to investigate the importance of consumers health valuations of five nutrients (saturated fat, sugar, carbohydrates, fibers and protein) relative to taste valuations for different types of foods (like e.g. meat, dairy, fats). The perfect substitutability of the health value of a given nutrient in different foods combined with decreasing marginal utilities of taste could have important implications for how consumers react to different policies.

Keywords: Hedonic model, taste, health, food consumption

JEL codes: D12, I12

1. Introduction and background

Unhealthy diet composition which can lead to cancer, cardiovascular disease, diabetes, and osteoporosis as well as overweight and obesity, is a growing problem in most modern societies. Therefore a broad range of policies aimed at influencing household food consumption are in use 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 chose to compose their diet as they do. In modern societies consumers often face a trade-off between health and taste, the latter which encourages consumption of fatty, salty and sweet foods, whereas health awareness discourages consumption of the same food. 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.

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 data set covering all components of a diet (including meat, fish, sugar-products etc.). 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*. This is facilitated by the broad coverage of our data and the hedonic price model which allows us to investigate the importance of decreasing marginal utility of the characteristics. More specifically the aim of this paper is to investigate the importance of consumers health valuations of five nutrients (saturated fat, sugar, carbohydrates, fibers and protein) relative to taste valuations for different types of consumers and foods (like e.g. meat, dairy, fats). The perfect substitutability of the health value of a given nutrient in different foods combined with decreasing marginal utilities of taste could have important implications for how consumers react to different policies.

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). What we do in the following is explicitly to model the nutrients' effect on these two different parts of the consumer's utility, which allows us to apply 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 *A:*

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

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 *B.*

If we assume that the consumer consumes one type of each good (the types characterised by containing the characteristics implied by technology matrices *A* and *B*) then the total amount of nutritional characteristics (given by vector *h* of *I* nutritional characteristics $h = (h_1, ...h_i, ...h_I))$ consumed by the household is:

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

While the total amount of non-nutritional characteristics consumed (given by vector *g* of *M* non-nutritional characteristics $g = (g_1, ...g_m, ...g_M))$ 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)
$$x_j = q_j k_j (\boldsymbol{a}_j, \boldsymbol{b}_j)$$

where q_j is the quantity of good *j* consumed and k_j is the quality of good *j* depending on the per unit content of various characteristics . $\boldsymbol{a}_j$ 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*). $\boldsymbol{a}_j$ is in principle determined by the consumers choice of quality in each period and $\boldsymbol{b}_j$ is the relevant vector of per unit non-nutritional characteristics from the technology matrix *B* again determined by the consumers choice of quality. The quality model that we are assuming is the simple repackaging model of quality. Thus different qualities of a good are perfect substitutes in the production of taste sub-utility in the sense that the marginal coefficient of substitution is independent of the chosen mix (one unit of a good can always perfectly substitute half a unit of the same good having twice as high quality $k_j\left(\boldsymbol{a}_j, \boldsymbol{b}_j\right)$). Essentially different qualities of a good just contain different fixed amounts of the quality adjusted base good.

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

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

This is in a rather 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 give health utility from 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 the taste characteristics in his food, the utility from the different heath characteristics utilities plus utility derived from expenditures on a numeraire good representing consumption of non-food goods. This is equal to income Y minus expenditures on the J different foods $\sum_{j=1}^{J} X_j$:

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

Thus we assume additive separability of the 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 $p_j(\boldsymbol{a}_j, \boldsymbol{b}_j)$ the consumer chooses both quantity and quality of each good so as to maximize normalized utility:

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

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 taste substitutes[1]. Conditional on optimal choice of quality the first order condition for optimal choice of quantity of good j is:

$$\text{(9)} \qquad p_j(\mathbf{a}_j, \mathbf{b}_j) = u'_j\left(q_1 k_1(\mathbf{a}_1, \mathbf{b}_1), ..., q_J k_J(\mathbf{a}_J, \mathbf{b}_J)\right) k_j(\mathbf{a}_j, \mathbf{b}_j) + \sum_{i=1}^{I} v'_i(h_i) a_{ji}$$

Where a_{ij} is the amount of nutrient i per unit of good j. Thus even though the marginal utility value of 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: $u'_j(x_1, ..x_J)$), we get, because of the assumed separability structure, that the marginal health utility value of nutrients only depends on the aggregate consumption of this nutrient. Further the separability implied by our quality model of goods implies that the taste quality function only depends on the characteristics contained in the specific good[2]. This is what allows us final identification in the empirical model.

Multiplying by q_j we get:

$$\text{(10)} \qquad X_j = u'_j\left(q_1 k_1(\mathbf{a}_1, \mathbf{b}_1), ..., q_J k_J(\mathbf{a}_J, \mathbf{b}_J)\right) k_j(\mathbf{a}_j, \mathbf{b}_j) q_j + \sum_{i=1}^{I} v'_i(h_i) h_{ji}$$

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[1] 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: $k_j(\mathbf{a}_j, \mathbf{b}_j) / p_j(\mathbf{a}_j, \mathbf{b}_j)$.

[2] 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 by over functional form.

Where X_j is expenditure on good *j* and h_{ji} is the total amount of nutrient *i* in the specific good.

3. Empirical specification

We assume quality is linear in non-nutritional characteristics. 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. We allow the same quadratic form for health utility of nutrients:

(11) $$X_j = u'_j\left(1+\boldsymbol{\alpha}_\mathbf{j}\mathbf{a}_j + \boldsymbol{\beta}_\mathbf{j}(\mathbf{a}_j \otimes \mathbf{a}_j) + \boldsymbol{\delta}\mathbf{b}_j\right)q_j + \sum_{i=1}^{I}\left(\gamma_i + \varepsilon_i h_i\right)h_{ji}$$

Since we have several periods in our data set we must allow u'_j to vary between these, since the vector of consumed food goods changes over time due to the optimization procedure in the first un-modelled nest – but because of our assumed separability quality and health utility parameters are constant over time. We do this by including time and good specific dummies for each representative household that we model so that the regression equations that we estimate become:

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

for all *j*. Where square brackets indicate data variables and *t* indicates time.

4. Data

Studies estimating hedonic price models have utilized both market and consumer level data. Market level data have come from a variety of sources, including auction records (Kristoffersen and Rickertsen, 2004; McConnell and Strand, 2000; Vickner and Koch, 2001). Consumer level data also arrive from a variety of sources, including supermarket scanner data, consumer surveys, and large, national databases such as the Nationwide Household Food Consumption Survey (Thunström, 2007; Lenz et al., 1994; Shi and Price, 1998; Teisl et al., 2003; Maietta, 2003). Despite the rich literature on hedonic pricing of foods only a limited amount of these are based on panel data. Exceptions are Huang and Lin, 2007, who uses AC Nielsen scannerdata and Thunström, 2007.

In the present paper we use detailed weekly purchase data for on average 2500 Danish households who report purchases of foods and other staples in terms of quantity, price and other product characteristics is collected in 2004.[3] The diary is filled in by the diary keeper and is sent to GfK on a weekly basis. In principle the diary is filled in immediately after each shopping trip. 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[4]. The nutrition data base provides detailed information about the content of macronutrients (as e.g. protein, fats, carbohydrates and fibres in 1032 different foods[5]. 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 possible level of detail. 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[6]. This results in a panel dataset at household level where the nutritional composition of purchases are measured together with prices and expenditure. As the level of the data are so detailed that some of them are provided at barcode level estimation of a whole diet model of these dimensions would in best case be very difficult, in worst case impossible so we follow the approach in Lenz et al, 1994 and construct 32 aggregate "qualities" which each consists of a number of underlying sub-qualities of the particular quality[7]. Prices and technology matrices are then constructed as average values from these *k* market goods:

Not all goods contain all types of nutrients. To estimate consumers' valuation of the taste and health attribute in their food it is necessary that the nutrients are known to the consumer and that the consumers are aware of the content of these nutrients in question for each of the goods. The most known and most discussed nutrients are carbohydrates, fibres, added sugar, protein, saturated fat and total energy ad they appear at the mandatory nutrient declaration labels. Due to massive correlation between the volume of foods and the measures of total energy the latter is removed from

[3] Data are provided by GfK Denmark, which maintains, among other activities, a consumer panel. For a throughout description of the data see Smed (2008)
[4] (http://www.foodcomp.dk/fcdb_default.asp)
[5] The database covered 1032 different foods in 2005, but is continuously improved
[6] For a detailed description of the concatenation of purchase data with the nutrition matrices see Smed (2008)
[7] The 33 goods are shown in appendix A

the equations. 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 278.84 grams of added sugar in one kilogram sugar products). 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 to 21 percent of total protein consumption while sugar-products contributes to 92 percent of total sugar consumption). The latter table is used to choose the variables in the model. Food categories that contributes to less than 2 % of total consumption of a specific nutrient is left out (e.g. it is assumed that fruits and vegetable do not contribute to the consumption of saturated fat).

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

	Dairy	Meat	Fats	Fruits and vegetables	Sugar products	Fish	Carbohydrate foods	Processed foods
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: The contribution from each food category to total nutrient consumption (5 of total consumption)

	Dairy	Meat	Fats	Fruits and vegetables	Sugar products	Fish	Carbohydrate foods	Processed foods	Total
Protein(g/kg)	21%	38%	0%	4%	4%	8%	22%	3%	100%
Carbohydrates (g/kg)	6%	1%	0%	10%	18%	1%	56%	8%	100%
Fibre (g/kg)	0%	1%	0%	31%	5%	0%	56%	7%	100%
Added sugar (g/kg)	3%	1%	0%	0%	91%	0%	4%	1%	100%
Saturated fat (g/kg)	22%	28%	34%	1%	8%	2%	3%	2%	100%

For the estimations we aggregate data to monthly observations and we use data only for 2004. In later versions of the model it is attended to increase the data with more years.

5. Preliminary results[8]

The model is estimated as a system of eight simultaneous equations using the NLSUR command in STATA 10.0. As the model is highly non-linear it is not straight forward to use standard panel data methods to account for unobserved heterogeneity so as a start we estimate the model using the data as a pooled panel dataset.

Table 3: Results from FGNLS regression

Equation	Obs	No. Parms	RMSE	R-sq
Total expenditure on fish	28922	20	28.8782	0.9780*
Total expenditure on dairy	28922	25	39.67697	0.9697*
Total expenditure on fats	28922	24	93.21414	0.9007*
Total expenditure on processed foods	28922	28	22.93035	0.8646*
Total expenditure on fruits and vegetables	28922	16	18.33983	0.9124*
Total expenditure on carbohydrate containing foods	28922	33	53.68125	0.9371*
Total expenditure on meat	28922	22	152.7682	0.9137*
Total expenditure on sugar products	28922	35	38.68757	0.9261*

* Uncentered R-square

The parameter values for the non-nutritional attributes and the good and time specific dummies are not shown; parameter values for the health and taste attributes of nutrients are shown in table 4 below.

Table 4: Parameter values - health

	Nutrient *i*	Good *j*	Coef.	Std. Err.	P>z
Common health parameter γ_i	Carbohydrates		0.0971	0.0123	0.0000
	Fibers		-0.8726	0.1246	0.0000
	Saturated fat		0.0954	0.0680	0.1610
	Sugar		-0.0708	0.0163	0.0000
	Protein		0.3589	0.0157	0.0000
Unique health parameter ε_{ij}	Carbohydrates	Carbo	3.48E-07	9.78E-08	0.0000
	Carbohydrates	Dairy	9.50E-07	2.86E-07	0.0010
	Carbohydrates	Fruits and vegetables	2.30E-06	6.10E-07	0.0000
	Carbohydrates	Processed food	2.89E-07	1.93E-07	0.1350
	Carbohydrates	Sugar products	-4.75E-07	2.08E-07	0.0220
	Fibre	Carbo	-0.000061	1.66E-05	0.0000
	Fibre	Fruits and vegetables	-5.87E-06	1.96E-05	0.7650
	Fibre	Processed food	-0.0000232	1.63E-05	0.1540
	Fibre	Sugar products	0.0003328	5.65E-05	0.0000
	Protein	Carbo	-5.72E-07	8.23E-07	0.4870

[8] These results are highly preliminary so please do not quote results without permission from the authors

Protein	Dairy	-2.54E-06	6.35E-07	0.0000
Protein	Fish	2.18E-06	1.25E-06	0.0810
Protein	Fruits and vegetables	-8.74E-06	5.10E-06	0.0870
Protein	Meat	-3.98E-06	2.03E-06	0.0500
Protein	Processed food	3.94E-06	1.76E-06	0.0250
Protein	Sugar products	-7.46E-06	6.26E-06	0.2330
Saturated fat	Carbo	-0.0000143	3.63E-05	0.6940
Saturated fat	Dairy	-0.0000182	4.78E-06	0.0000
Saturated fat	Fats	-1.66E-06	1.80E-06	0.3580
Saturated fat	Fish	-0.0000226	2.31E-05	0.3280
Saturated fat	Meat	-0.0000155	1.39E-05	0.2650
Saturated fat	Processed food	-5.08E-06	2.58E-05	0.8440
Saturated fat	Sugar products	-8.11E-06	1.02E-05	0.4270
Sugar	Carbo	5.52E-06	1.94E-05	0.7760
Sugar	Dairy	-9.85E-06	3.05E-05	0.7470
Sugar	Sugar products	-2.13E-06	1.72E-06	0.2140

Table 5: Parameter values - taste, α_{ij} and β_{ij}

Nutrient *i*	Good *j*	Coef.	Std. Err.	P>z
Carbohydrates	Carbo	-0.01534	0.00718	0.03300
	Dairy	-0.06174	0.01331	0.00000
	Fruits and vegetables	-0.07659	0.01800	0.00000
	Processed food	-0.12724	0.02103	0.00000
	Sugar products	-0.01268	0.02178	0.56100
Carbohydrates_squared	Carbo	0.00000	0.00000	0.00000
	Dairy	0.00000	0.00001	0.47800
	Fruits and vegetables	-0.00003	0.00001	0.00000
	Processed food	0.00000	0.00001	0.46900
	Sugar products	0.00000	0.00000	0.88700
Fibre	Carbo	0.05586	0.03289	0.08900
	Fruits and vegetables	0.02901	0.05525	0.60000
	Processed food	1.61401	0.15764	0.00000
	Sugar products	0.00000	0.00000	0.00000
Fibre_squared	Carbo	0.00008	0.00003	0.00100
	Fruits and vegetables	0.00058	0.00015	0.00000
	Processed food	-0.00198	0.00046	0.00000
	sugar products	-0.00602	0.00238	0.01200
Protein	Carbo	0.06171	0.06890	0.37100
	Dairy	0.03851	0.01706	0.02400
	Fish	-0.19921	0.02258	0.00000
	Fruits and vegetables	-0.12588	0.11877	0.28900
	Meat	0.02640	0.00765	0.00100
	Processed food	-0.40172	0.11985	0.00100

	Sugar products	-0.30519	0.11221	0.00700
Protein squared	Fish	-0.00002	0.00001	0.00100
	Carbo	0.00004	0.00003	0.08800
	Dairy	-0.00002	0.00001	0.03300
	Fruits and vegetables	-0.00091	0.00027	0.00100
	Meat	0.00000	0.00000	0.31300
	Processed food	0.00040	0.00039	0.30400
	Sugar products	0.00004	0.00022	0.85300
Saturated fat	Carbo	-0.00016	0.04802	0.99700
	Dairy	0.00347	0.01676	0.83600
	Fats	-0.01478	0.00730	0.04300
	Fish	0.05441	0.11199	0.62700
	Meat	-0.07481	0.02312	0.00100
	Processed food	0.08871	0.14945	0.00000
	Sugar products	-0.01052	0.09276	0.91000
Saturated fat squared	Fish	-0.00041	0.00037	0.26700
	Carbo	0.00001	0.00007	0.89800
	Dairy	0.00001	0.00007	0.89800
	Fats	-0.00005	0.00003	0.07300
	Meat	0.00000	0.00000	0.12500
	Processed food	0.00001	0.00002	0.73000
	sugar products	-0.00009	0.00189	0.00000
Sugar	Carbo	-0.00006	0.00014	0.68200
	Dairy	0.12751	0.05775	0.02700
	sugar products	0.03822	0.04889	0.43400
Sugar_squared	Carbo	-0.00138	0.02691	0.95900
	Dairy	-0.00029	0.00038	0.44900
	sugar products	0.00000	0.00059	0.99900

As the main interest in this paper is the consumer's trade-off between health and taste values in the food that he is consuming we will here show a few figures of how these results can give insight in this trade-off. The first two figures show the marginal valuation of the health attribute of nutrient consumption. This value consists of a constant term, common for all types of goods γ_i and a term which is unique for each good ε_{ij}, but depends on the amount of nutrient consumed.

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

As these results are very preliminary we only show the results for saturated fat and sugar. Figures for all nutrients will be provided when the final results are estimated. Figure 1 shows the marginal valuation of health attribute from saturated fat for the goods that contains fat for various amounts of total fat while figure 2 contains the same marginal values for sugar.

Figure 1: Marginal health value of saturated fat

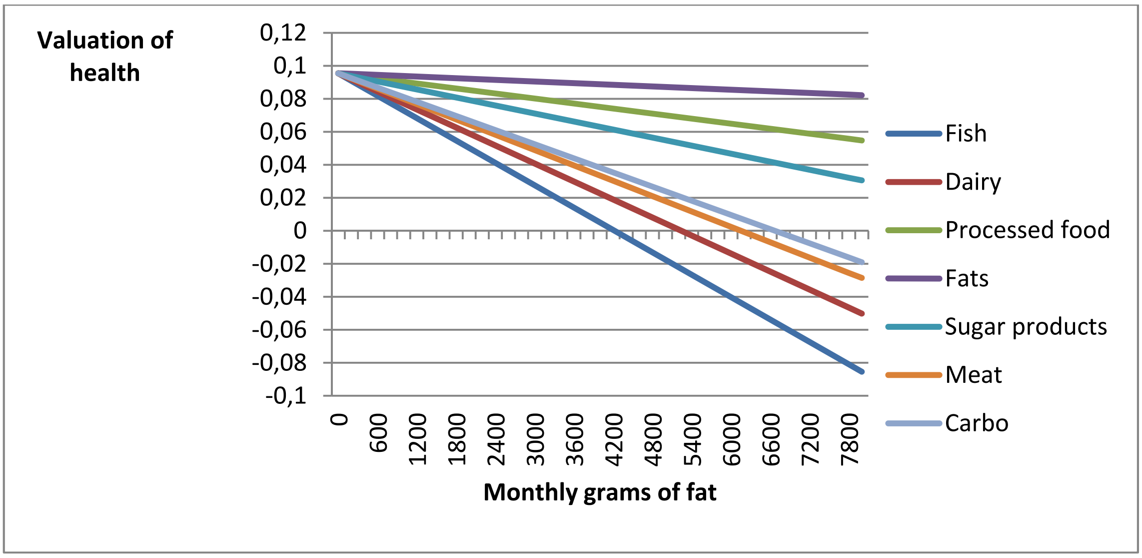
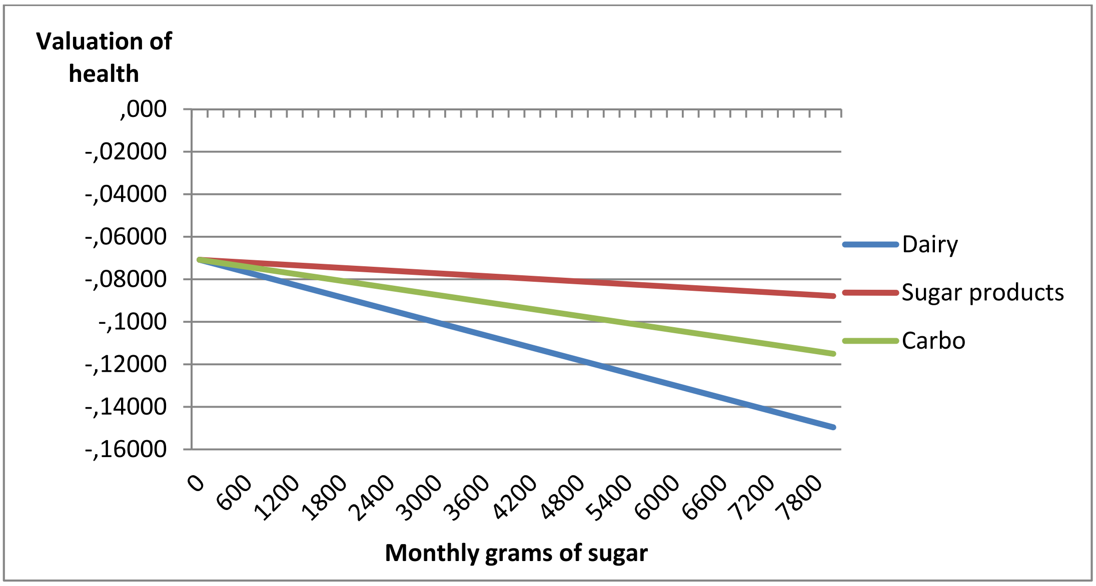


Figure 2: Marginal health value of sugar



The graphs in figure 1 show an initial positive valuation of saturated fat, but with different degrees of decreasing marginal valuation. Fat from fish, dairy, meat and carbohydrate containing foods have a more negative valuation than fat from other types of goods. The graph in figure 2 shows that sugar has a general negative marginal valuation. Sugar is valued unhealthier when it originates from dairy than from sugar products.

The next two figures show the marginal valuation of the taste attribute of nutrient consumption. These values consists of a constant term α_{ij} unique for each good and nutrient and a second term β_{ij} also unique for each good and nutrient, but dependent on the amount of nutrient in a specific amount of the god in question i.e. the taste attribute of nutrients are valued according to how much of the nutrient in question is consumed.

$$(14) \qquad Marginal\,Valutation_{taste,ij} = \alpha_{ij} + \beta_{ij}\left[\frac{h_{ij}}{q_j}\right]$$

Figure 3 shows the marginal valuation of health attribute from saturated fat for the goods that contains fat for various amounts of total fat. The values are on the x axis are chosen to reflect possible values of the content of fat in the considered goods i.e. from 2g/kg which is below the average content for carbohydrate containing foods to 402 g/kg which is above the average value of fat per gram of fats. Figure 4 contains the same marginal values for sugar where the values on the x-axis again are chosen to reflect possible values of the content of sugar in the goods i.e from 2g/kg which is below the average value for dairy products to above 402 g/kg which is above the average value of sugar per gram of sugar products.

Figure 3: Marginal taste value of saturated fat

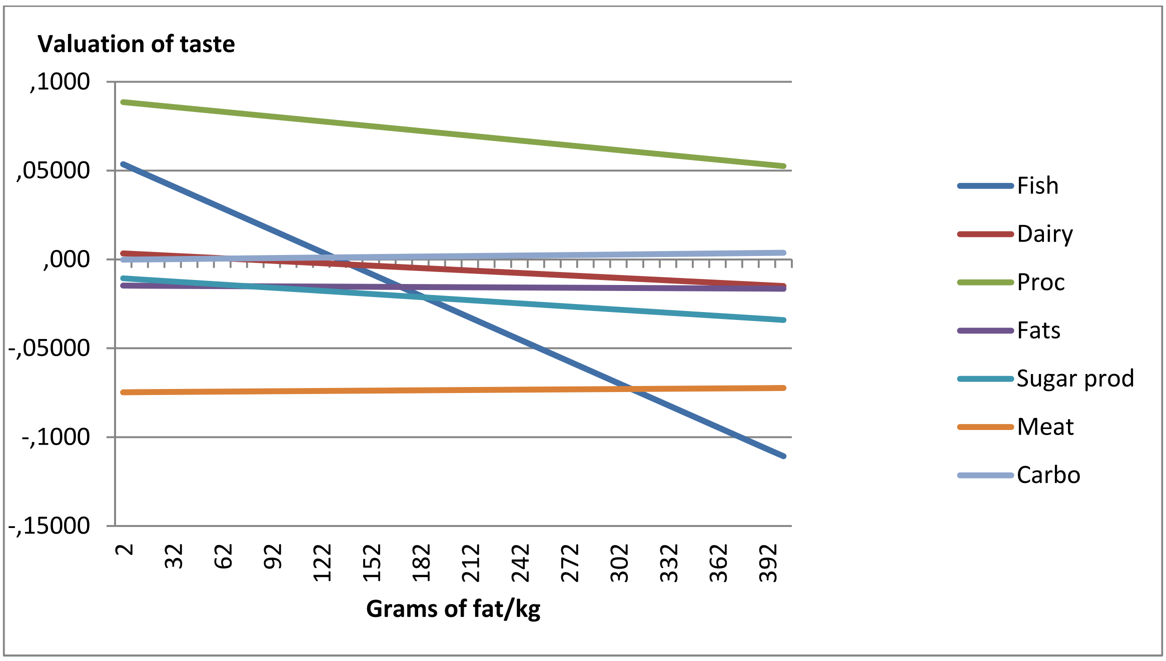
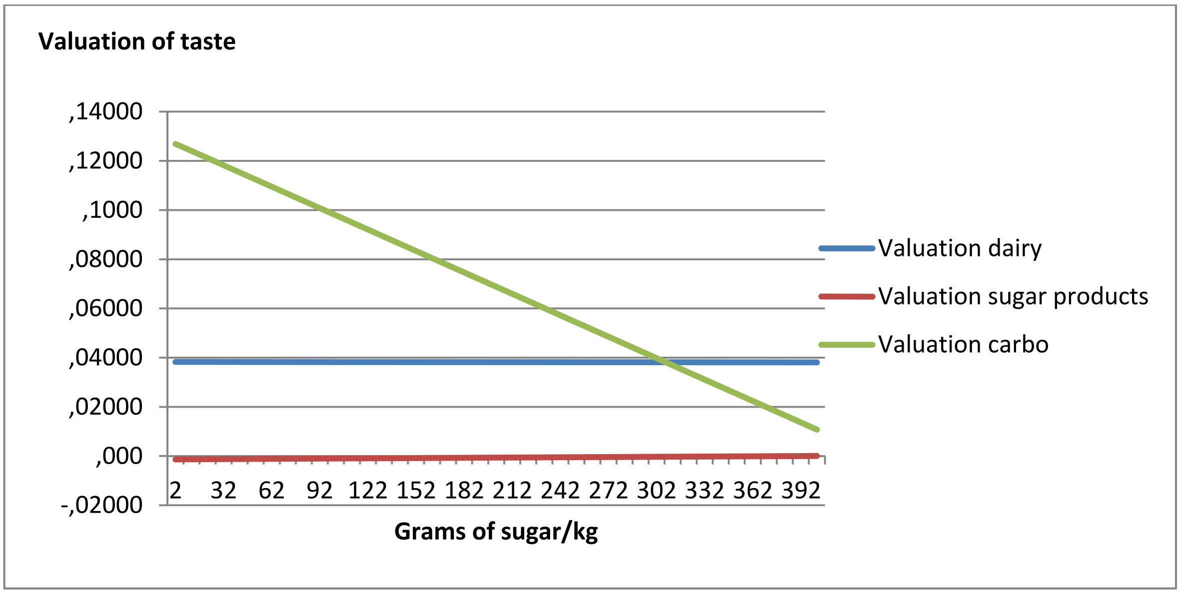


Figure 4: Marginal taste value of sugar



Fish, processed food and dairy are considered to have an initial positive taste value from fat, while meat, sugar products and fats are considered to give negative marginal utility. As dairy has decreasing marginal utility dairy products with some fat are considered to have better taste than dairy products with higher amounts of fat. Sugar seems to contribute positively to taste for especially carbohydrate containing goods.

6. 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. Even though the results shown in this paper are very preliminary the graphs pictured in the result section indicates the possibilities inherent in using the model that we have developed. If we take sugar as an example, consumers value the health consequences of consuming sugar negatively. This is especially true when the sugar is contained in dairy or carbohydrate containing foods. On the contraire sugar contributes positively to the taste experience for carbohydrate containing foods. This indicates that whenever the consumer are induced to cut back on sugar consumption, carbohydrate containing foods might not be the first food to choose. The next step in this paper is to calculate a measure for the inherent trade-off from this negative health value in combination with the positive taste value. In the end of the day these results will make it possible for us to grasp the basic tradeoff between the immediate pleasures of taste and gratification associated with a certain dietary composition and the long term health consequences this implies. The perfect substitutability of the health value of a given nutrient in different foods combined with decreasing marginal utilities of taste could have important implications for how consumers react to different policies and hereby how we could be able to change consumer behavior regarding diets.

7. References

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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	Processed foods
Sauce		
Salad dressing etc.		
Ketchup		
Pizza	Dishes	
Dishes with rice and pasta		
Chocolate (for bread)	Spreadable	Sugar products
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	Carbohydrate containing goods
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	