The Marginal Willingness-to-Pay for Health Related Food Characteristics*

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Abstract

With food, consumers often face a trade-off between taste and nutrition. A priori, it is not obvious which would be more important to the average consumer, so it is an empirical question how consumers value food characteristics that simultaneously affect taste and nutritional value. In this paper, Swedish consumer preferences regarding food characteristics in breakfast cereals, hard bread and potato products are analyzed. In particular, the value consumers attach to fat, fibre, salt and sugar is studied, as well as the value of easily accessible nutritional information provided by a nutrition symbol. The equations estimated are derived from a hedonic price model. The price data originates from a household panel and scanner data, whereas the corresponding data on food characteristics was collected manually in supermarkets or from producers. The value consumers attach to food characteristics are found to vary by product and the results also imply that these values could be sensitive to changes in the combination of characteristics in a product.

Keywords: hedonic pricing; willingness to pay; food characteristics.
JEL classification: D1; I1.

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1. Introduction

Being overweight or obese may contribute to serious health problems, such as diabetes, heart disease, several types of cancer, and muscle disorders, as well as social exclusion, causing individual suffering and imposing substantial costs on individuals and society as a whole.[1] In many parts of the world, overweight and obesity have risen dramatically in recent decades. While the cause has been debated, several studies point to altered eating habits, i.e., higher intake of calories (Putnam et al. 2002, Cutler et al. 2003).

The main objective of this study is to analyse how consumers value health related food characteristics. We do so by analysing how consumers value food characteristics that are highly associated with obesity, i.e. particularly unhealthy food characteristics, such as fat, salt and sugar, as well as health improving characteristics, such as fibre and transparent nutritional information provided by a nutrition symbol. The relationship between these characteristics and over-consumption of food is discussed below.

Birch (1999) and Smith (2003) suggest that the ability of modern food supply to exploit consumer preferences for energy-dense food has led to increased intake of calories. Evolution provided us with means of gaining information as to the nutritional value of food. To be on the safe side, we learned to prefer fatty, sweet, and salty foods, since fat is energy dense, sweet foods (e.g., fruits and berries) contain important vitamins and antioxidants; and salt is vital to maintaining chemical balance in the body. Modern technology in food production has taken fattiness, sweetness and saltiness to new extremes. At the same time, nutritional value is often lost in food processing. As opposed to in pre-industrialized societies, relying on taste as the sole source of nutritional information today might even put our health at risk. Also, food processing has made nutritional information less transparent, since consumers cannot directly observe what is contained in the refined product. Even though nutritional information may be readily available on the food package, collecting information is costly, in terms of time to compare the nutritional information on products and even in learning to understand the information. Consumers often act on incomplete information, which can increase consumption of unhealthy foods (Kin et al., 2000). The easily accessible information provided

[1] Definitions of overweight and obesity are usually based on Body Mass Index (BMI), measured as the weight of a person (in kilograms) divided by their squared height (in meters): a BMI of 25-30 is considered overweight and a BMI above 30 is considered obese.

by nutrition symbols, on the other hand, can contribute to a healthier consumption (Neuhouser et al, 1999).

In industrialized societies, there is a trade-off between taste and health, concerning many types of food. Taste encourages consumption of fatty, salty and sweet foods, whereas health awareness discourages consumption of the same foods. Which of these effects dominates is an empirical question, important to answer if we want to understand what is driving the increase in obesity. The value consumers attach to food characteristics also affects food supply, by providing firms with incentives or disincentives to supply healthy food.

In this paper, hedonic price models are estimated on breakfast cereals, hard bread and potato products, in order to gain knowledge on the value consumers attach to fat, fibre, salt, sugar and a nutrition symbol. These three product groups were chosen for two reasons: they constitute important parts of a modern diet, and each of these product groups contains a wide variety of products that differ substantially in their nutritional content, while still being close substitutes.[2]

Hedonic price models, launched by Lancaster (1966) and further developed and formalised by Griliches (1967, 1971) and Rosen (1974), have been widely used to estimate marginal implicit prices of characteristics for which markets do not exist.[3] Hedonic pricing methods have been used to calculate implicit marginal prices for characteristics of housing (see, for example, Benson et al., 1998, and Mills and Simenauer, 1996). Other areas of application are computer attributes (Bajari and Benkard, 2005) and lately even the attributes of baseball players (Stewart and Jones, 1998) and the services of prostitutes (Moffatt et al. 2004).

Stanley and Tschirhart (1991) and Shi and Price (1998) use the hedonic price method to estimate how consumers value characteristics in breakfast cereals. Stanley and Tschirhart focus on the estimation of a hedonic price function for a non-durable good, using nutritional

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[2] Potato products might be the weakest group in terms of close substitutes. Even though mashed potatoes can substitute for French fries and French fries can substitute for potato chips, mashed potatoes might not be considered a (close) substitute for chips.

[3] A change in food consumption over the last decades has been the shift away from home-made food to packaged or pre-prepared food. The general increase in consumption of unhealthy food ingredients, such as fat, salt and sugar, is therefore not due to an increase in consumption of these goods in their pure forms, but rather due to the average consumer eating pre-prepared food that contains high amounts of these ingredients. To gain knowledge on how consumers value fat, salt and sugar, it is therefore necessary to analyse them as part of a product, i.e. not settle for the market prices of these ingredients.

data on breakfast cereals. Shi and Price analyse how socio-demographic variables (income, level of education, number of children, and age) affect the values attached by consumers to characteristics of breakfast cereals, including non-nutrient characteristics such as type of grain. They find that energy (calories) is positively valued by all consumer groups, whereas fat is negatively valued, as is fibre. Both Stanley and Tschirhart and Shi and Price find a positive effect of sugar on the price of breakfast cereals, and Stanley and Tschirhart find a negative effect of fibre.

This study extends these studies in three ways. First, the analysis goes beyond breakfast cereals, by including other staple goods, i.e. bread and potatoes. Second, product characteristics are also combined with national average prices for the specific products, thereby providing a more accurate measure of the dependent variable than Stanley and Tschirhart, who collected the prices for their study from a limited number of supermarkets. Third, this is the first analysis of this type using Swedish data.

The outline of the paper is as follows. Section 2 presents the theory behind hedonic models. Section 3 describes the data, and Section 4 describes the empirical method. Section 5 presents the results, while Section 6 summarizes and draws conclusions.

2. Theoretical model

Suppose that consumers derive utility from consumption of a staple good (e.g., breakfast cereals, hard bread, or potato products) and a composite good (all other consumption). Following the modification by Stanley and Tschirhart (1991) of the work by Rosen (1974), it is assumed that the utility derived from consumption of the staple good depends on the "services" it provides, rather than the quantity consumed. The services provided by staple food are considered to be taste, nutrition, and convenience, where convenience is thought of as being inversely related to preparation time of the food. The utility function of the representative consumer can then be written as

$$U = \widetilde{U}(s_1, s_2, s_3, X) \tag{1}$$

where s_1, s_2 and s_3 are the services taste, nutrition and convenience of the staple good, and X is the composite good. Utility is assumed to increase in each argument and to be strictly concave. The services associated with the staple good are, in turn, assumed to be determined by the n characteristics of the particular food product; content of berries, fruit, nuts and vitamins, grams of carbohydrates, fat, fibre, protein, salt and sugar, as well as the amount of kilo joule, presence of the nutrition symbol and preparation time. Let $\mathbf{z} = z_1, ..., z_n$ denote these characteristics. We can define $s_h = s_h(\mathbf{z})$, for h = 1,2,3. Each characteristic can affect several services simultaneously and oppositely; e.g., fat might affect taste positively, but the nutritional value negatively. The utility function can therefore be rewritten as

$$U = \widetilde{U}(s_1, s_2, s_3, X) = \widetilde{U}(s_1(\mathbf{z}), s_2(\mathbf{z}), s_3(\mathbf{z}), X) = U(\mathbf{z}, X) \tag{2}$$

Although utility is assumed to be increasing in all services, it can either increase or decrease in particular characteristics. If, for instance, the negative effect of fat on the nutritional value outweighs its positive effect on taste, utility will decrease in fat.

For simplicity, it is also assumed that the consumer only purchases one unit of the staple good. Normalizing the price of the composite good to one, the individual budget constraint then becomes

$$M = P(\mathbf{z}) + X \tag{3}$$

where M is income, measured in units of the composite good; $P(\mathbf{z})$ is the market price of the staple good, assumed to be a function of the characteristics. The price function, $P(\mathbf{z})$, is continuously differentiable in the elements of **z**. Since the staple good is differentiated (for example; there are several types of breakfast cereals with different combinations of characteristics), the market price of the good varies over different types of the staple good. Therefore, the consumer is able to affect the price paid for the good by choosing the levels of characteristics in the good. The market price function itself cannot be influenced by the consumer, however. The utility maximizing consumer thus chooses the level of characteristic i such that

$$p_i = U_{z_i} / U_X \qquad i = 1,...,n \qquad (4)$$

where $p_i = \partial P(\mathbf{z}) / \partial z_i$, $U_{z_i} = \partial U / \partial z_i$, and $U_X = \partial U / \partial X$.

Equation (4) means that the increase in the price of the staple good from adding another unit of characteristic *i* is equal to the marginal rate of substitution between characteristic *i* and the composite good. In other words, the consumer chooses a combination of characteristics such that the change in the product price, from a marginal increase in a particular characteristic, equals the marginal willingness to pay for that characteristic.

As mentioned above, the marginal utility of the composite good is positive, but the marginal utility of characteristic *i* can be either positive or negative since the characteristic can enter several services simultaneously and in opposing ways. Therefore, the marginal implicit price of characteristic *i* can be either positive or negative; signing the marginal implicit price of a characteristic is thus an empirical question.

3. Data and expected effects of food characteristics

Data on characteristics (ingredients, nutritional information and the presence or not of a nutrition symbol) has mostly been collected manually from packages in supermarkets in Sweden, but also from producer websites, and sometimes from producers directly. The data set is, therefore, limited to include only observations of staple goods that were either found in the stores when gathering ingredients and nutritional values, or for which the characteristics were available from producers. All in all, there are 86 observations on breakfast cereals, 71 observations on hard bread, and 44 observations on potato products.

Average national prices of top-selling Swedish processed potato products (potato chips, frozen potato products, and mashed potato products) were calculated from scanner data, provided by AC Nielsen Sweden, on weekly total national volume and value sold, week 1 through 42, in 2004. GfK Sweden provided data on prices of breakfast cereals and hard bread from their 2003 household panel (daily observations throughout the full year). Average yearly prices for breakfast cereal and hard bread products are calculated on this data. The price data contained in the GfK household panel reflects the prices faced by panel members when making their purchases. Since this price data consist of prices faced by consumers, it could be affected by the mix of households in the panel. Worth noting is that individuals of age 65 and over are slightly over represented. The data contains no information on for example regional representation.

The national Swedish nutrition symbol; the "Keyhole", is certified by the Swedish Food Administration, based on certain criteria (see SLVFS 1989:2 and LIVSFS 2005:9). There are no potato products certified with the Keyhole symbol in our sample. The Keyhole symbol was found on a sizeable share of both breakfast cereal products and hard bread, though. For breakfast cereals, the certification criteria of the Keyhole cover fat, fibre (or whole grain), salt and sugar content; for bread, the criteria cover fat, fibre and salt content.[4]

The level of detailed nutritional information varies substantially over products. The Appendix presents summary statistics on the characteristics of all three food groups, and other information that appeared on the product package. All characteristics are measured in grams per 100 gram. For all products, information was recorded on energy density (kilo joules), fat, carbohydrates, and protein. For breakfast cereals and hard bread, sugar and fibre content were recorded as well. This information was lacking for potato products, for which both the sugar and fibre content is low and vary little over products, though. The main unhealthy ingredients in potato products are fat and salt, which were recorded. For breakfast cereals, the presence of berries, fruit, and nuts was collected. For potato products, the time required to prepare the food in the oven was recorded for consistency, even in cases where other cooking alternatives existed (such as micro waving or frying).

Following Stanley and Tschirhart (1991), Table 1 shows the expected effect on services of each food characteristic included in the regression analysis of particular relevance for health.

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[4] The Keyhole certification criteria were revised in 2005 (LIVSFS 2005:9) and then became stricter than they were before (SLVFS 1989:2). Potentially there could therefore be breakfast cereal or hard bread products in the data that fulfilled the Keyhole certification criteria in 2003, when the price data was collected, that do not fulfill the criteria now and hence were not found to carry the Keyhole symbol when characteristics data was collected in stores. Such products, if any, are expected to be very few, though.

Table 1 – Expected effects of selected food characteristics on food services

Food characteristic	**Service**		
	Taste	Nutrition	Convenience
Fat	(+)	(-)	(+)
Fibre	(+/-)	(+)	(+)
Salt	(+)	(-)	(+)
Sugar	(+)	(-)	(+)
Vitamins	no effect	(+)	(+)
Nutrition symbol	no effect	no effect	(+)

Most characteristics in Table 1 are expected to affect more than one service, and in opposing ways. The exceptions are vitamins and the nutrition symbol. Vitamins do not affect taste, and are therefore expected to have a positive effect on overall utility, by affecting both nutrition and convenience positively. They are assumed to affect convenience positively since consuming vitamins as part of food is more convenient than consuming vitamin supplements separately. The nutrition symbol informs consumers about the nutritional (i.e. health) status of the product and, by representing easily accessible nutritional information, thus affecting convenience positively. The nutrition symbol is expected to have no effect on taste or nutrition, since it only reflects the content of other characteristics. For the rest of the characteristics, an expected sign of the effect on utility, and thus the willingness to pay, cannot be determined a priori. For most consumers, fat, salt, and sugar are all assumed to affect taste positively, due to our underlying preferences for sweet, salt and fatty food, and to simultaneously affect nutrition negatively. Fibre, on the other hand, is expected to affect nutrition positively, while the taste effect is less clear. Even though consumers in modern Western societies more often over consume, rather than under consume, fat, salt and sugar (hence the negative effect on the nutrition service), consumers need a certain minimum intake of energy each day, and preferably also a certain intake of fibre and salt. Therefore, fat, fibre, salt and sugar are also expected to have a positive impact on convenience.

4. Empirical method

Assuming that data was generated as described by the theoretical model, the marginal implicit prices of food characteristics can be estimated from a hedonic price function. The functional form of the hedonic price function is an open question, since economic theory provides no guidance here. Semi-log regressions, or linear or quadratic functional forms of Box-Cox transformed variables, have often been used in hedonic regressions. Cropper et al. (1988) find that the performances of various model specifications in hedonic regressions depend on the quality of the data. They conclude that a linear function of Box-Cox transformed variables performs best under perfect information about relevant characteristics. In the case of omitted variables or proxies, the linear function of Box-Cox transformed variables is outperformed only by a hedonic price function with untransformed variables. However, the use of Box-Cox transformations has been criticized. Cassel and Mendelsohn (1985) conclude that the results from the Box-Cox transformation are both hard to interpret and unstable. Also, even a general form of the Box-Cox transformation is restrictive in that it requires the functional form to be the same for all transformed exogenous variables. The quadratic model provides a flexible functional relationship and, in addition, encompasses the linear-in-variables model as a special case. The quadratic model is therefore used here. Multicollinearity is severely enhanced if both linear and quadratic terms of the same variables are included in the regression, though. Therefore, the square of the difference between the measured value of a characteristic and the mean value for that characteristic is used instead of a quadratic term of the characteristic. The following hedonic price function is estimated for product group *j* (where *j* = breakfast cereals, hard bread or potato products)

$$P_j^k = \alpha_j + \sum_{i=1}^{m} \beta_{ji} z_{ji}^k + \sum_{i=1}^{m} \delta_{ji} (z_{ij}^k - \bar{z}_{ij})^2 + \boldsymbol{\gamma}_j \tilde{\mathbf{z}}_j^k + \boldsymbol{\varphi}_j \mathbf{D}_j^k + \varepsilon_j^k \tag{7}$$

where P_j^k is the price per 100 gram of product *k* (where $k = 1,...,K$) in group *j*, m is the number of *continuous* characteristics (of a total of *n* characteristics) in the product; and $\bar{z}_{ji}$ is the mean content of characteristic *i* in product group *j*, i.e. $\bar{z}_{ij} = \sum_k z_{ij}^k / K$. The vector $\mathbf{D}_j^k$ contains dummy variables for discrete characteristics (indicators of the nutrition symbol, berries, fruit, nuts and vitamins) as well as indicators of the *q* brands in the data on product group *j*. Included in the regression is also a vector of interaction terms, defined as $\tilde{\mathbf{z}}_j^k = (z_{j1}^k z_{j2}^k, z_{j1}^k z_{j3}^k, z_{j1}^k z_{j4}^k, z_{j2}^k z_{j3}^k, z_{j2}^k z_{j4}^k, z_{j3}^k z_{j4}^k)$, where characteristics 1, 2, 3 and 4 are fibre, salt, sugar and fat, respectively. These terms show how combinations of characteristics particularly associated with the nutritional status of the product are valued by consumers. For example, although fibre alone might not be valued highly, fibre in combination with salt might be, meaning that consumers only value additional fibre highly if the staple good at the same time contains a high amount of salt.

This model specification differs from the one used by Stanley and Tschirhart (1991) mainly in that they estimate a hedonic regression specified as a linear Box-Cox function. The main difference from the model chosen by Shi and Price (1998) is that they estimate a linear regression, using more aggregated food product data, and also include interaction terms with household characteristics. Neither Stanley and Tschirhart nor Shi and Price include interaction terms between variables, or control for brand effects, both of which are done here.

The functional relationship between the product price and characteristics is determined by the statistical significance of the effects of the linear, quadratic, and interaction variables. After estimating the hedonic regressions for each product group as specified by equation (7), *F*-tests were performed to determine whether otherwise statistically non-significant parameter estimates jointly contribute to the explanatory power of the model and therefore should not be excluded from the model. If they did not, as a group, contribute to the explanatory power of the model, they were excluded.

For hard bread, there are values missing on salt and sugar for 22 out of 71 observations. Using the information provided in the data set, conditional means were imputed, based on all other independent variables; missing values were thus estimated by regressing salt and sugar on the remaining independent variables. While admittedly raising the problem of multicollinearity, filling in missing values with the imputed ones produces consistent estimates (Little, 1992). Note that the results from the imputation differed little from estimates produced by replacing missing values with mean values of the available levels of the characteristics.

The Cook-Weisburg test for heteroscedasticity was performed. For breakfast cereals and hard bread, the null hypothesis of homoscedasticity cannot be rejected. For potato products, it can be rejected, however. As a result, White's heteroscedasticity-consistent estimator of the variance-covariance matrix was used when testing hypotheses for potato products.

A model with each observation weighted by its market share has also been estimated, as a means of ensuring that popular products found in stores be given greater weight in the empirical analysis than products rarely found in the stores, since the latter products would often not be part of the choice set faced by consumers. Since food characteristics were collected manually in stores anyway, the most commonly found products are already highly represented in the data. The results from the weighted regressions thus do not differ much from the baseline hedonic regression and are not reported.

Differentiating equation (7) with respect to the *i*th characteristic, gives the marginal implicit price of characteristic *i* in product group *j*, which we denote p_{ji}. The marginal implicit price of (continuous) characteristic *i* is then

$$p_{ji}^{k} = \beta_{ji} + 2\delta_{ji}(z_{ji}^{k} - \overline{z}_{ji})(1 - 1/K) + \sum_{h=1}^{H} \gamma_{jh} z_{jh}^{k} \qquad i \neq h \tag{8}$$

where $z_1,...,z_H$ are the contents of the *H* continuous characteristics by which characteristic *i* interacts. Following Stanley and Tschirhart (1991) and Shi and Price (1998), the marginal implicit prices are evaluated at the mean content of the characteristics in the product group. However, only analyzing marginal implicit prices calculated at the mean contents of the product means missing valuable information on how the willingness to pay for a food characteristic depends on the level of the characteristic contained in the product, and also on the level of other characteristics. Therefore, sensitivity analyses has been performed, to provide transparent information on the change in the marginal implicit price of selected characteristics from changes in the content of characteristics. Such analyses provide insight into how the trade-off between the taste and health effect from one characteristic can be affected both by the level of the characteristic itself and by the contents of other characteristics.

5. Results

We start by discussing the results from the estimations of the hedonic price function. Thereafter, we continue by analyzing the mean marginal implicit prices, i.e. the marginal implicit prices evaluated at the mean product content, and how they change as the product content (marginally) changes.

5.1 Results from the hedonic price regressions

Tables 2-4 show the results of the hedonic regressions, as specified in equation (7), with explanatory variables that either individually or jointly (as determined by the *F*-test) contribute to explaining variations in the product price. In the following, parameters referred to as having a statistically significant effect are statistically significant at the 5 percent level, unless otherwise stated. When commenting on the results, focus will be on five characteristics, i.e. the nutrition symbol, fat, fibre, salt and sugar. As noted earlier, brand dummies were included as controls in the model, but the effects of these variables are not presented.

The results from the hedonic regression on ***breakfast cereals*** reveal a statistically significant negative effect on price, at the 10 percent level, of the *nutrition symbol*, which contradicts the a priori expectation about consumers valuing the easily accessible information the symbol presents. The linear term for *fat* has no significant effect on the price, but the quadratic term has a highly significant negative effect. The same is true for *salt*. Also for *fibre*, the quadratic term has a significant effect, this time positive. Our results also imply that *sugar* has a positive and decreasing effect on the price, with the parameters of the linear and quadratic terms being highly significant. None of the interaction terms have significant effects on the price of breakfast cereals.

The positive effect of sugar is consistent with the results in both Stanley and Tschirhart (1991) and Shi and Price (1998). Shi and Price do not have salt as an explanatory variable in their analysis and Stanley and Tschirhart find no statistically significant effect of salt. Our results, however, suggest that salt has a negative effect on the price of breakfast cereals. Contrary to the results here, Stanley and Tschirhart find a significant negative effect of fibre.[5]

The explanatory power of the regression on breakfast cereals is high; the R square value being 0.86. Most of the quadratic terms have a significant effect on the price of breakfast cereals, whereas the linear terms do not. Also, none of the interaction terms has a significant effect on

[5] For comparison with Stanley and Tschirhart, a Box-Cox transformation was performed. The qualitative effects of most explanatory variables remained as in Table 2, with the exception of sugar and vitamins. Also, as shown by an *F*-test, brand dummies strongly enhance the explanatory power of the model. As a comparison, a hedonic price function without brand dummies was also estimated. The signs of parameter estimates statistically significant in the full model were the same, and even the levels of these parameters estimates did not change much, though often the estimates were no longer statistically significant.

the price. An F-test value of 2.59 (P-value = 0.01) shows that, as a group, the linear and interaction terms jointly contribute to the explanatory power of the model, and they are therefore included in the model.

Table 2 – Results from the hedonic regression on breakfast cereals

Variable	Coefficient	Variable	Coefficient
$z_{nutritionsymbol}$	-109.01* (-1.90)	z_{salt}	-26.49 (-0.09)
z_{vit}	-51.86 (-1.17)	$(z_{salt} - \overline{z}_{salt})^2$	-542.99** (-2.06)
$z_{berries}$	95.06** (3.27)	z_{sugar}	10.48** (2.76)
z_{fruit}	15.55 (0.39)	$(z_{sugar} - \overline{z}_{sugar})^2$	-0.50** (-3.00)
z_{nuts}	20.95 (0.44)	$z_{fat} z_{fibre}$	-0.11 (-0.07)
z_{carbs}	3.21 (0.49)	$z_{fat} z_{salt}$	13.64 (0.67)
$(z_{carbs} - \overline{z}_{carbs})^2$	0.33 (0.80)	$z_{fat} z_{sugar}$	-44.32 (-0.60)
z_{fat}	10.69 (0.39)	$z_{fibre} z_{salt}$	8.73 (0.28)
$(z_{fat} - \overline{z}_{fat})^2$	-2.22** (-2.58)	$z_{fibre} z_{sugar}$	-0.99 (-1.48)
z_{fibre}	-17.20 (-0.88)	*Constant*	-154.17 (-0.25)
$(z_{fibre} - \overline{z}_{fibre})^2$	2.79** (2.23)	R^2 : 0.86	
$z_{protein}$	62.07** (4.21)		
$(z_{protein} - \overline{z}_{protein})^2$	-14.14** (-4.71)		

Superscript * indicates that the variable has a statistically significant effect at the 10 percent level and superscript ** indicates that the effect is significant at the 5 percent level; t-values are in parentheses.

For ***hard bread*** products, the coefficient for the *nutrition symbol* has the expected positive sign, but is not statistically significant. A positive effect from *fat* on price is statistically significant at the 10 percent level. The effect of *fibre* is negative but not statistically significant. Similarly, no statistically significant effect is found for *salt* or *sugar*. As with breakfast cereals, none of the interaction terms have statistically significant effects on the price. The large number of non-significant estimates is reflected in the lower explanatory power of the model; R square being 0.63.[6] The lack of significant parameter estimates could

[6] The F-test shows that removing the brand dummies from the model does not significantly reduce the explanatory power of the model. Without them, the signs of the statistically significant parameter estimates in the full model are still the same, except for the quadratic term for protein, which is positive, but non-significant.

be because there is less variation in the data on hard bread than in that on breakfast cereals and potato products. Hard bread is generally healthy, which is shown by the high proportion of hard bread products being certified with the nutrition symbol (see Appendix). Variables which individually had no significant effect on the hard bread price jointly increased the explanatory power of the model (*F*-test = 1.72, P-value = 0.09), so they were included in the model.

Table 3 – Results from the hedonic regression on hard bread

Variable	Coefficient	Variable	Coefficient
$z_{nutritionsymbol}$	131.31 (1.16)	z_{sugar}	-360.84 (-1.10)
z_{carbs}	41.05* (1,69)	$(z_{sugar} - \overline{z}_{sugar})^2$	20.09 (1.39)
$(z_{carbs} - \overline{z}_{carbs})^2$	3.06 (1.01)	$z_{fat} z_{fibre}$	-15.20 (-1.56)
z_{fat}	329.62* (1.83)	$z_{fat} z_{salt}$	111.30 (0.56)
$(z_{fat} - \overline{z}_{fat})^2$	-28.32** (-3.00)	$z_{fat} z_{sugar}$	-9.65 (-0.70)
z_{fibre}	-83.55 (-0.71)	$z_{fibre} z_{salt}$	215.12 (1.20)
$(z_{fibre} - \overline{z}_{fibre})^2$	-2.46 (-0.56)	$z_{fibre} z_{sugar}$	22.03 (1.05)
$z_{protein}$	35.25 (1.00)	*Constant*	-2053.77 (-0.92)
$(z_{protein} - \overline{z}_{protein})^2$	-26.59** (-2.04)	R^2 : 0.63	
z_{salt}	-3046.31 (-1.03)		
$(z_{salt} - \overline{z}_{salt})^2$	1293.59 (0.30)		

Superscript * indicates that the variable has a statistically significant effect at the 10 percent level and superscript ** indicates that the effect is significant at the 5 percent level; *t*-values are in parentheses.

For ***potato products***, the quadratic terms for carbohydrates and fat, as well as the linear term for protein, have no individually significant effects on the product price. An *F*-test also reveals that including these terms, as a group, does not increase the explanatory power of the model.[7] Therefore, they are excluded from the model. For potato products, the positive effect of *fat* on the product price is highly statistically significant. Here, the interaction term between fat and salt is also highly significant, and negative, counteracting the positive effect of fat on

[7] Brand dummies strongly contribute to the explanatory power of the model, however. Without them, the parameter estimates that are individually statistically significant in the full model are still the same both in sign and level. However, the parameter estimates of the effect from carbohydrates and the quadratic terms for carbohydrates, fat and protein, are statistically significant in the reduced model. All still have the same sign as in the full model, except for the parameter estimate of the effect from carbohydrates.

the product price. The explanatory power of the reduced regression on potato products is still high; the R square value of the regression amounts to 0.92.[8]

Table 4 – Results from the hedonic regression on potato products

Variable	Coefficient
$z_{prep.time}$	-0.04** (-3.14)
z_{carbs}	-0.07 (-1.52)
z_{fat}	0.14** (2.37)
$(z_{protein} - \bar{z}_{protein})^2$	-0.14 (-1.54)
z_{salt}	4.29** (8.58)
$z_{fat} z_{salt}$	-0.47** (-6.39)
Constant	20.22** (8.31)
R^2 : 0.92	

Superscript * indicates that the variable has a statistically significant effect at the 10 percent level and superscript ** indicates that the effect is significant at the 5 percent level; *t*-values are in parentheses.

Based on the results shown in Tables 2-4 above, marginal implicit prices are calculated (Table 5, below). As also done by Stanley and Tschirhart (1991), and Shi and Price (1998), marginal implicit prices are calculated at the mean values of the food characteristics. Mean marginal implicit prices are expressed in öre (100 öre = 1 SEK). For each continuous characteristic, the mean marginal implicit price is the amount that consumers are willing to pay for a small increase of this characteristic above its mean value, all other characteristics being at their mean values. For the nutrition symbol, the marginal implicit price indicates consumers' willingness to pay for having the label on the product.

The mean marginal implicit price of *fat* varies greatly over the three product groups. Consumers seem to value fat in hard bread (149 öre), indicating that the positive effect on

[8] A model linear in all variables (with brand dummies) was estimated for comparison, for all product groups. The main difference in the results from estimating the linear model occurred for breakfast cereals; the individual effects on the price of fibre and sugar turned insignificant. Also, the prevalence of multicollinearity is high in all models, although dramatically reduced compared to models where both the linear and quadratic terms of the same variables are included, as indicated by high mean variance inflation factors. However, for breakfast cereals and potato products, in turn removing collinear variables leaves the individually statistically significant parameter estimates almost identical to the estimates provided by the full model. In turn removing the most collinear variables from the hard bread group also leaves the sign of the individually statistically significant parameter estimates the same, but the absolute value of those parameter estimates drop by about one third.

taste from adding fat outweighs the negative effect on nutrition. The opposite is true for breakfast cereals, shown by its large negative mean marginal implicit price (-863 öre). In potato products, the outcome of the trade-off between taste and nutritional value concerning fat seems to depend on whether or not the product contains salt. If the product contains salt, consumers on average have a negative marginal willingness to pay for fat, whereas consumers on average have a positive marginal willingness to pay for additional fat if the product does not contain salt. With salt, the positive effect on taste from a marginal increase in fat seems to be outweighed by the negative effect on nutrition from decreasing the fat content. In both cases, however, the mean marginal implicit price of fat in potato products is small.

The mean marginal implicit price of *fibre* is positive, but non-significant, for hard bread, whereas for breakfast cereals it was negative. This could imply that marginally increasing fibre above its mean level in breakfast cereals reduces the taste, and that this reduction in taste outweighs the positive effect on the nutrition.

The mean marginal implicit price for *salt* is positive both for breakfast cereals and hard bread, although non-significant for the latter group. For the potato products it is negative, however, though quite small. The values are not strictly comparable, though, since salt is included as a dummy in the hedonic regression on potato products. The negative marginal implicit price therefore reflects a negative willingness to pay for adding salt to potato products that contain no salt.

The mean marginal implicit price for *sugar* in breakfast cereals is negative and fairly large (-294 öre) so the negative effect on nutrition from a small increase in the sugar content outweighs the positive effect on taste. The marginal implicit price for sugar in hard bread is also negative, though non-significant.

Table 5 – Marginal implicit prices, evaluated at the mean content

Breakfast cereals		**Hard bread**		**Potato products**	
Nutrition symbol	-109.01	Nutrition symbol	131.31	Preparation time	-0.04
Vitamins	-51.86	Carbohydrates	41.05	Carbohydrates	-0.07
Berries	95.06	Fat	149.42	Protein	-0.28
Fruit	15.55	Fibre	17.38	Salt	-3.80
Nuts	20.95	Protein	35.25	Fat	
				- if salt	-0.33
Carbohydrates	3.21	Salt	300.02	- if no salt	0.14
Fat	-862.77	Sugar	-85.50		
Fibre	-34.53				
Protein	62.07				
Salt	128.51				
Sugar	-293.99				

100 öre = 1 SEK

5.2 Results from sensitivity analysis

Table 6 below shows the effect on the marginal implicit price of selected continuous characteristics from a 1 percent change in the levels of these characteristics.

It is important to exercise caution in the interpretation of the results: the only interaction term with an individually statistically significant effect in the hedonic regressions is the interaction term between fat and salt in potato products. The lack of other individually significant parameter estimates means that the results from the sensitivity analysis should merely be seen as an illustration of the fact that marginal implicit prices may vary over levels of characteristics.

By using the point estimates in Table 2-4, we find that for breakfast cereals, the marginal implicit price of fat decreases, i.e., becomes more negative, as the level of fat is increased above the mean level. The marginal implicit prices of both salt and sugar in breakfast cereals also decrease as the level of the characteristic itself is increased, suggesting that consumers have a diminishing marginal willingness to pay for these characteristics in breakfast cereals. However, the opposite is true for the marginal implicit price of fibre, which increases as the level of fibre increases by one percent above its mean level. Noteworthy is also that the percentage change in the marginal implicit price as the characteristic itself is increased by one percent seems to be quite small for fat (-0.03 percent) and sugar (-0.06 percent), whereas it is fairly sizeable for fibre (1.21 percent) and especially for salt (-3.01 percent) in breakfast cereals.

In hard bread, there is a diminishing marginal willingness to pay for fat and fibre, whereas the marginal willingness to pay for salt and sugar seems to be increasing, as the level of the characteristic itself increases. Also here, the percentage changes of the marginal implicit prices are the smallest for fat (-1.20 percent) and sugar (1.02 percent), as the content of the characteristic itself is increased by one percent above its mean level, compared to the change in the marginal implicit prices for fibre (-3.88 percent) and salt (4.00 percent) in hard bread.

The results from the sensitivity analysis also suggest that, in both breakfast cereals and hard bread, consumers value salt more if the fibre content increases, and vice versa. This could be interpreted as consumers appreciating the taste enhancing effect from salt even more when the fibre content is high. Bearing in mind that we are looking at marginal changes, if this result is general, it would mean that producers have an incentive to add salt to products rich in fibre, which would decrease the health status of products with a high fibre content.

The results also imply that consumers value salt more if the fat content raises (at least in breakfast cereals and hard bread) and vice versa. This suggests that the dominance of taste over nutrition is even stronger with higher levels of both fat and salt; a possible interpretation is that the taste sensation of the combination of fat and salt is strong.

Table 6 – Marginal implicit price changes from changing levels of health characteristics

	Breakfast cereals	Hard bread	Potato products
Effects on the marginal implicit price of fat			
Mean p_{fat}	**-862.77**	**149.42**	**-0.33/0.14**
Percentage change of p_{fat} if increasing fat by 1%	-0.03%	-1.20%	n.a.
Percentage change of p_{fat} if increasing fibre by 1%	-0.001%	-1.41%	n.a.
Percentage change of p_{fat} if increasing salt by 1%	0.01%	0.35%	n.a.
Percentage change of p_{fat} if increasing sugar by 1%	-1.01%	-0.14%	n.a.
Effects on the marginal implicit price of fibre			
Mean p_{fibre}	**-34.53**	**17.38**	n.a.
Percentage change of p_{fibre} if increasing fat by 1%	-0.02%	-2.80%	n.a.
Percentage change of p_{fibre} if increasing fibre by 1%	1.21%	-3.88%	n.a.
Percentage change of p_{fibre} if increasing salt by 1%	0.09%	5.80%	n.a.
Percentage change of p_{fibre} if increasing sugar by 1%	-0.57%	2.79%	n.a.
Effects on the marginal implicit price of salt			
Mean p_{salt}	**128.51**	**300.02**	**-3.79**
Percentage change of p_{salt} if increasing fat by 1%	0.69%	1.19%	-2.13%
Percentage change of p_{salt} if increasing fibre by 1%	0.50%	9.96%	n.a.
Percentage change of p_{salt} if increasing salt by 1%	-3.01%	4.00%	n.a.
Effects on the marginal implicit price of sugar			
Mean p_{sugar}	**-293.99**	**-85.50**	n.a.
Percentage change of p_{sugar} if increasing fat by 1%	-1.01%	-0.36%	n.a.
Percentage change of p_{sugar} if increasing fibre by 1%	-0.03%	3.58%	n.a.
Percentage change of p_{sugar} if increasing sugar by 1%	-0.06%	1.02%	n.a.

The marginal implicit prices are in öre.

6. Summary and conclusions

In this study, consumers are assumed to derive utility from food that is tasty, convenient and has a high nutritional value. Often there is a trade-off between taste and nutrition, since food rich in particularly unhealthy ingredients (fat, salt and sugar) may also be very tasty. We do not know, a priori, whether taste or nutrition dominates to consumers, when valuing these ingredients. If taste dominates for some ingredient, consumers will have a positive willingness to pay for it, whereas if nutrition dominates, their willingness to pay will be negative. The purpose of this study is to estimate the values attached by consumers to particularly health related food characteristics; fat, fibre, salt and sugar and the nutrition symbol.

Calculating mean marginal implicit prices for fat, fibre, salt and sugar in breakfast cereals, hard bread and potato products, we find that the dominance of taste over nutrition, or vice versa, varies both over health characteristics and over food products. Nutrition dominates taste for fat in breakfast cereals and in potato products that contain salt, whereas taste dominates nutrition for fat in hard bread and in potato products that do not contain salt. Taste also dominates nutrition for salt in breakfast cereals and hard bread, resulting in a positive mean marginal implicit price (or marginal willingness to pay) for salt in these products. For salt in potato products, the reverse seems to be true, however. For sugar in breakfast cereals and hard bread, nutrition seems to dominate over taste, resulting in a negative marginal willingness to pay for sugar in both breakfast cereals and hard bread. As for the one particularly healthy ingredient, fibre, the marginal willingness to pay for fibre in breakfast cereals is estimated to be negative, whereas the reverse is true for the marginal willingness to pay for fibre in hard bread.

The marginal implicit prices for fat, fibre, salt, and sugar are sensitive to the levels of both the characteristic itself and other food characteristics. A negative marginal willingness to pay for a characteristic that is calculated on the basis of the mean contents of the product might thus turn positive with another combination of food characteristics in the product. This will affect producer incentives to develop healthy products. If, for instance, the marginal willingness to pay for a healthy ingredient (fibre) is positively affected by adding an unhealthy ingredient (such as salt), producers would have an incentive to add salt to products rich in fibre. However, it is important to exercise caution in interpreting the results of this sensitivity analysis, due to the low statistical significance of individual parameters in the hedonic regressions. More research is needed in order to understand consumer preferences for combinations of ingredients.

The nutrition symbol helps consumers judge the nutritional status of a product, and the symbol was, a priori, expected to be positively value by consumers. However, the nutrition symbol on breakfast cereals seems to have a negative marginal implicit price, whereas the effect on the price from the nutrition symbol on hard bread could not be statistically confirmed. There are no examples of potato products with the nutrition symbol in our data set. The average consumer thus seems to provide producers with disincentives to apply for certification for the nutrition symbol. A negative marginal implicit price for the nutrition symbol seems counter intuitive. If it would be that, on average, consumers regard the nutrition symbol not only as a source of information, but also as a signal for poor taste, such a result could be expected, though.

The fact that consumers have a negative marginal willingness to pay for some characteristics raises the question of why producers continue offering products with such combinations of characteristics. One reason could be that they have incomplete information on consumer preferences and hence the marginal willingness to pay for attributes. Also, consumer preferences change over time, for instance due to new health findings, and producers might be slow to change their products accordingly. In addition, producers often supply a portfolio of products that vary in contents; the profit maximizing portfolio could include products that individually yield varying profits. Also, preferences vary over consumers. Therefore, even if the average consumer has a negative willingness to pay for a characteristic, there may be sub-groups of consumers with different tastes, constituting niche markets for producers. Such differences in preferences over socio-demographic groups are confirmed by Shi and Price (1998). Their results show that the value attached to energy (kilo joule) in food varies over age groups, with the young attaching a higher value to energy than older consumers. People with higher education were also found to attach a lower value to fat than other consumer groups. In a similar way, Larsson et al. (1999) found that different consumer groups react differently to the nutrition symbol. If preferences for the nutrition symbol vary, there might be groups with a positive willingness to pay for the nutrition symbol, providing producers with incentives to apply for the certification for the nutrition symbol.

To understand the underlying mechanisms of consumer food preferences and producer incentives as part of the explanation for obesity, more research is needed both on the supply side of the market and on the differences in preferences over consumer groups. These are important topics to address in future research.

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Appendix

Summary statistics for food products

	Breakfast cereals	Hard bread	Potatoes
Price per 100 grams*			
Mean price	4.3 SEK	4.4 SEK	5.3 SEK
Min price	1.7 SEK	1.7 SEK	1.3 SEK
Max price	9.6 SEK	8.7 SEK	10.2 SEK
Kilo joule per 100 grams			
Mean content	1583 KJ	1395 KJ	1308 KJ
Min content	1350 KJ	1103 KJ	240 KJ
Max content	1900 KJ	1720 KJ	2321 KJ
Carbohydrates per 100 grams			
Mean content	69.7 grams	64.7 grams	35.2 grams
Min content	52.0 grams	45.0 grams	12.0 grams
Max content	87.0grams	80.0 grams	59.0 grams
Fat per 100 grams			
Mean content	6.7 grams	3.2 grams	17.2 grams
Min content	0.5 grams	0.3 grams	0.5 grams
Max content	18.0 grams	11.0 grams	38.0 grams
Fibre per 100 grams			
Mean content	7.6 grams	13.9 grams	
Min content	1.0 grams	3.8 grams	n.a.
Max content	20.0 grams	27.1 grams	
Protein per 100 grams			
Mean content	9.0 grams	10.0 grams	4.1 grams
Min content	4.5 grams	3.5 grams	1.5 grams
Max content	16.0 grams	13.0 grams	6.0 grams
Salt per 100 grams**			
Mean content	0.36 grams	0.47 grams	n.a. (dummy)
Min content	0 grams	0.20 grams	(32 obs contain
Max content	0.95 grams	0.80 grams	salt)
Sugar per 100 grams**			
Mean content	19.8 grams	2.2 grams	
Min content	0.8 grams	0.1 grams	n.a.
Max content	44.0 grams	12.0 grams	
Food preparation time			
Mean time			9 min 20 sec
Min time	0 min	0 min	0 min
Max time			60 min
Number of obs with nutrition symbol	18	52	n.a.
Number of obs with berries	18	n.a.	n.a.
Number of obs with fruit	26	n.a.	n.a.
Number of obs with nuts	9	n.a.	n.a.
Number of obs showing vitamin info	43	n.a.	n.a.
Number of brands	14	8	6
Total number of obs	86	71	44

*On October 10 2006, USD/SEK = 7.39.
** For hard bread, there are missing observations of salt and sugar, such that the values presented here are based on both actual and predicted observations of these variables.