The Impact of Tax Reforms Designed to Encourage a Healthier Grain Consumption*

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Abstract

In this paper, we simulate the effects of taxes on products and/or nutrients aimed at encouraging a healthier grain consumption. To carry out the analysis, we use a rich data set on household consumption of grain products, combined with information about the nutritional content of the products. We estimate behavioural parameters that are used to simulate the impact on the average household of different types of tax reforms; entailing either a subsidy on commodities particularly rich in fibre or a subsidy of the fibre density in grain products. Our results suggest that to direct the fibre intake of the average household towards nutritional recommendations, reforms with a substantial impact on consumer prices are required. Our results also imply that subsidizing the fibre density is more cost-efficient than reducing the VAT on commodities rich in fibre. Regardless of the type of subsidy imposed, the increase in the fibre intake is accompanied by unwanted increases in nutrients that are often over consumed; fat, saturated fat, salt and sugar and added sugar. Funding the subsidies by taxing these nutrients, or less healthy commodities, prevents such developments.

Key words: Consumer economics, food, health, taxation

JEL classification: D12, H23, I18

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1. Introduction

Over the last few decades, technological change has contributed to advances both in food production and transportation, leading to a more cost-efficient food production and higher availability of processed and pre-prepared foods. As a result, welfare has been enhanced by falling relative prices of food. The other side of the coin is that the modern diet, combined with a more sedentary life-style, has proven to be an important determinant of a number of severe illnesses, such several types of cancer, cardiovascular disease, diabetes, osteoporosis, dental caries and also overweight and obesity, themselves major risk factors of many of the illnesses mentioned. Cancer and cardiovascular diseases account for almost two thirds of the total disease burden in Europe, and poor nutrition is estimated to cause about one third of the deaths caused by cancer and one third of cardiovascular diseases (WHO, 2004). Conservative estimates suggest that poor nutrition is the cause of 4.6 percent of total losses of years of healthy lives in the European Union, and that obesity and overweight accounts for another 3.7 percent (National Institute of Public Health, 1997).

The negative health effects caused by modern food consumption also impose considerable burdens on health care budgets and, hence, on tax payers. In the U.S., direct costs on health care from poor nutrition and too little exercising are estimated to account for 7 percent of personal health care expenditures (Kenkel and Manning, 1999). In Germany, diet-related diseases have been estimated to account for 30 percent of total costs of health care, including both direct and indirect costs (Kohlmeier et al., 1993). Obesity and overweight alone have been estimated to account for direct costs on the Swedish health care system of 3.6 billion SEK (Persson et al. 2004), and indirect costs of 12.4 billion SEK (Persson et al. 2005). Should current trends prevail, diet-related costs on society will increase even further. The externalities imposed on tax payers could justify government intervention aimed at encouraging a healthier food consumption.[1]

In this paper, we analyze the effects of tax reforms aimed at directing the fibre intake towards nutritional recommendations provided by public authorities.

Increasing the intake of dietary fibre is one of the most important means to achieve a healthier food consumption. A high intake of dietary fibre has several health promoting effects, such as

[1] It has also been argued by some, though, that diet related diseases might be a result of externalities that individuals impose on themselves. For a comprehensive review of, among other things, externalities that could justify policy interventions to improve the dietary quality, see Strnad (2004).

helping to keep a healthy body weight (Burton-Freeman, 2000, Liu et al., 2003), controlling and preventing heart diseases (Liu, 1999, Mann, 2002), diabetes (Brand-Miller et al., 2003, Schulze et al., 2004, Willet et al., 2002), colon cancer (Larsson et al., 2005) and even gum disease (Merchant et al., 2006). Due to the positive health effects from a diet rich in fibre, the Swedish National Food Administration (SLV) recommends that the average Swedish consumer greatly increases his/her fibre intake. The average woman is recommended to increase her intake by a minimum of 56 percent, whereas the average man is recommended to increase his intake by a minimum of 38 percent.[2]

The most important source of dietary fibre is grain products, along with fruit and vegetables. Grain products is also the food group that contributes the most to our daily energy intake[3], as well as perhaps contains the greatest variety of food products, in terms of health status of the food.[4] In this study, we therefore focus on the effects of tax reforms on grain consumption.

The nutritional recommendations stated above provide us with the overall policy objective of increasing the fibre intake from grain consumption by a minimum of 38 percent.[5] To translate this into recommendations on grain product consumption, the SLV recommends that the average person (a) doubles her overall intake of bread and breakfast cereals, while (b) ensuring that half of the bread and breakfast cereal consumption carry the healthy label certified by the SLV; the “Keyhole” (SNÖ 2003).[6]

To carry out the analysis, we estimate a demand system for grain products based on two micro data sets; household expenditure data on grain products from GfK Sweden, a private market

[2] The average woman consumes 112 grams of dietary fibre per week, whereas the average man consumes 126 grams per week (Becker and Pearson, 2002). Recommended weekly levels are at 175-245 grams of dietary fibre for both men and women (SNR, 1997).

[3] According to statistics collected by the Swedish Board of Agriculture, the consumption of grain products makes up around a third of the total energy intake for the average Swedish consumer, per day. In 2003, grain products made up 18 percent of total food expenditures, while food expenditures made up 12 percent of total household expenditures (Statistics Sweden, Household Budget Survey, 2003).

[4] Whole grain products are considered to be part of a healthy diet, whereas white, highly refined grain products are often classified as “empty calories”; food that is energy dense and at the same time low in nutritional content.

[5] Worth stressing is that the recommended increase in the fibre intake is general and considers all food groups, i.e. is not specific for grain consumption. However, by assuming that the increase in the fibre intake should be proportional for all food groups, we use the general recommendations on increased fibre intake as the policy objective for the fibre intake from grain products. To simplify, we also assume that the recommended minimum increase of the fibre intake for the average man (38 percent) holds for the average consumer, i.e. regardless of gender.

[6] SLV certifies the Keyhole symbol to breakfast cereals fulfilling the following criteria: fat content: max 7g/100g, sugar content: max 13g/100g, sodium content: max 500mg/100g and fibre: min 1,9g/100 kcal. For soft bread, the certification criteria are: fat content: max 7g/100g, sugar content: max 10g/100g, sodium content: max 600mg/100g and fibre: min 1,9g/100 kcal, whereas the certification criteria for hard bread are: fat content: max 8g/100g, sodium content: max 600mg/100g and fibre: min 1,9g/100 kcal.

research company, and household expenditure data on soft bread from Statistics Sweden. The parameters estimated in the demand system are thereafter used to simulate the results of tax reforms aimed at directing grain consumption towards the above policy objectives. Taxes or subsidies on both the commodity and nutrient level are considered; we simulate the results from reforms entailing subsidies of Keyhole labelled products, as well as reforms containing a subsidy of the fibre density of the product. We also simulate the results of revenue neutral reforms, where these subsidies are funded by commodity taxes on goods, or excise duties on nutrients, that are often over consumed by Western food consumers.

There is a growing theoretical literature on the effects of economic policy instruments designed to improve health (see e.g. O'Donoghue and Rabin, 2003, and Aronsson and Thunström, 2006), but empirical research on the subject is limited. Dejgaard Jensen and Smed (2007) conclude that it is less costly to achieve an increase in the fibre intake from subsidizing the fibre content directly, compared to subsidizing products rich in fibre. Smed et al. (2007) find that subsidies of fibre, or products rich in fibre, lead to unwanted increases in the intake of less healthy nutrients, though. Chouinard et al. (2007) analyse the effect of imposing ad valorem taxes on the fat percentage in milk products and conclude that these taxes have small effects on the intake of fat. They also find the tax to be highly regressive. Finally, Kuchler et al. (2005) find that ad valorem taxes on salty snack foods that range from 0.4 – 30 percent would have small effects on consumer behaviour and the dietary quality.

There are some countries where small taxes on unhealthy foods, such as soft drinks, snacks or junk food, have been imposed (Australia, Canada, Finland, Norway and the U.S., for example). However, these taxes are generally aimed at generating public revenues, rather than affecting consumer behaviour (Jacobson and Brownell, 2000). The fact that countries have already imposed differentiated VAT rates, based on the health status of foods, further enhances the importance of empirical research on the effects of such policy measures.

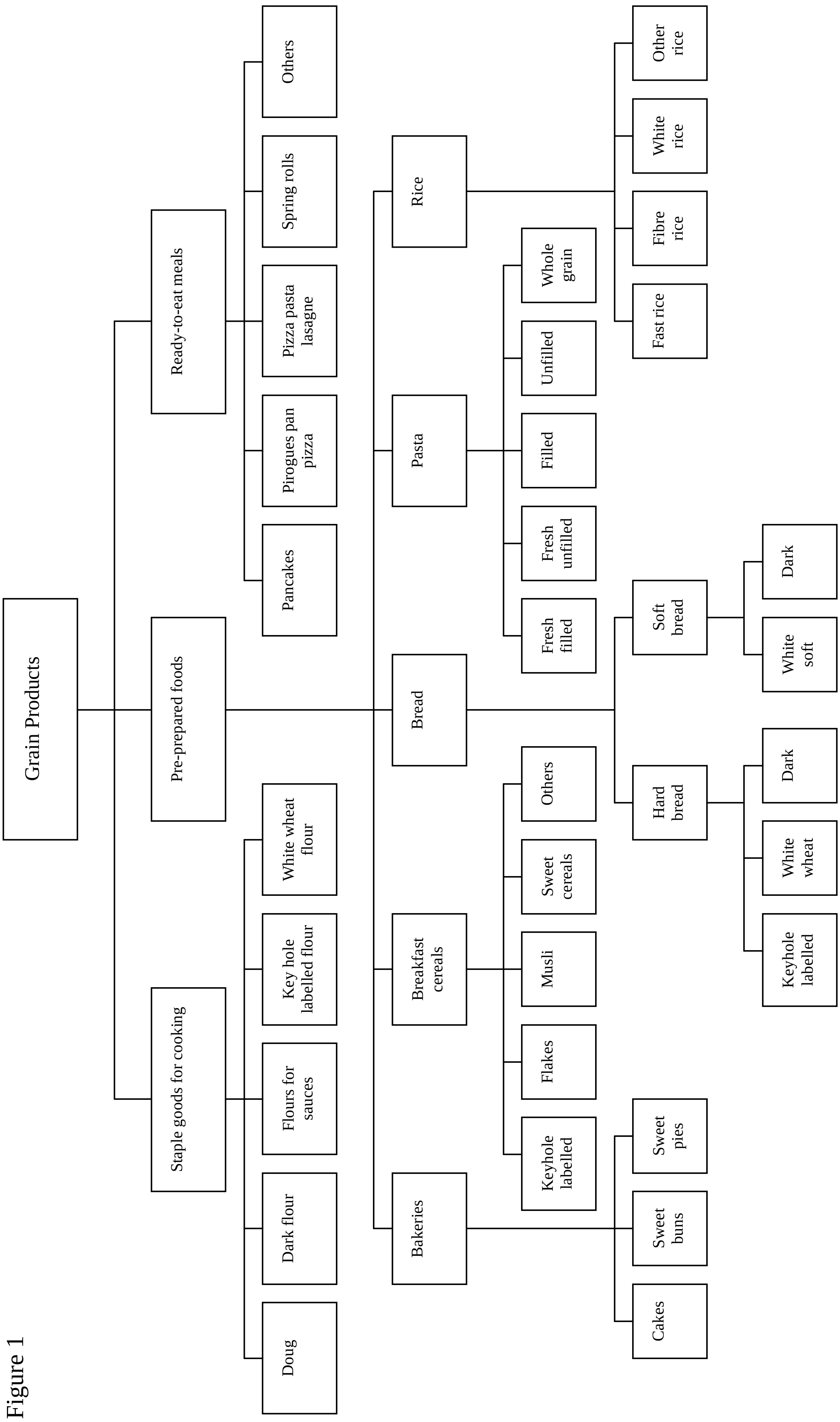
To the best of our knowledge, this is the first study analyzing the effects from policy instruments that are designed to direct consumption towards specific nutritional recommendations. This paper therefore provides unique and valuable insights into the impact of tax schemes that could be used to improve the quality of the modern diet, or even attain nutritional recommendations.

The outline of the paper is as follows. In Sections 2 and 3, we present the modelling framework and data used to estimate the demand system for grain products. Section 4 contains the estimation results. In Section 5, the simulations are described and Section 6 contains the simulation results. Finally, Section 7 summarizes and concludes.

2. Modelling Framework

We believe that the decision process can be illustrated by Figure 1, where households allocate expenditures over grain products in multiple steps. At the highest level in the decision process, the household allocates its (total) resources for grain expenditures between three broad product categories; pre-prepared foods, ready-to-eat-meals and staple goods for cooking. When the household has determined the expenditures for each category, it decides how to allocate these expenditures between the product groups within each category.

Figure 1


Grain Products
Staple goods for cooking
Pre-prepared foods
Ready-to-eat meals
Doug
Dark flour
Flours for sauces
Key hole labelled flour
White wheat flour
Pancakes
Pirogues pan pizza
Pizza pasta lasagne
Spring rolls
Others
Bakeries
Breakfast cereals
Bread
Pasta
Rice
Cakes
Sweet buns
Sweet pies
Keyhole labelled
Flakes
Musli
Sweet cereals
Others
Hard bread
Soft bread
Keyhole labelled
White wheat
Dark
White soft
Dark
Fresh filled
Fresh unfilled
Filled
Unfilled
Whole grain
Fast rice
Fibre rice
White rice
Other rice

2.1 Estimating the demand system

To model demand for grain products we use the microeconomic data sets described in Section 3 below, and the multi stage allocation process shown in Figure 1. However, we cannot observe the households' total consumption of grain products (some are consumed outside the home in e.g. restaurants and school refectories). The relative intake of different grain products is likely to be well reflected in the data set, though, suggesting that a demand system based on budget shares is preferred to a demand system based on quantities or expenditures for the goods.

Also, consumer demand patterns typically found in micro-data sets vary considerably across households with different household characteristics and levels of income. As indicated in Banks et al. (1997), expenditures on some goods are non-linear in total expenditure (or income) while some are linear.

A flexible functional form of consumer preferences, based on budget shares and with the capacity to handle non-linear expenditure effects, is the quadratic extension (Banks et al. 1997) to Deaton and Muellbauer's (1980) almost ideal demand system (AIDS). We therefore use the quadratic AIDS (QAIDS) model as our basic model specification. We take into account the differences in consumption patterns between household categories, by adding intercept and slope parameters in the budget share equations of the demand system. As we can not observe the households consumption of other goods, we have to assume that household preferences are weakly separable in grain consumption and other goods. To reduce the number of estimated parameters, we also assume that household preferences are weakly separable in ready to eat meals, staple goods for cooking and pre-prepared foods. The full decision process and the separability assumptions that follow from this process are shown in Figure 1.

We therefore estimate a demand system where the allocation decision is made in several steps. Preferences are characterised in such a way that household h makes decisions on how much of grain products to consume conditional on various household characteristics, **d**. Household h's budget share for good k, s_k^h, in the first allocation stage (i.e. the allocation of resources over staple goods for cooking, pre-prepared foods and ready-to-eat meals) then takes the form

$$s_k^h = a_k(\mathbf{d}^h) + \sum_l g_{kl} \ln p_l^h + b_k(\mathbf{d}^h) \times \ln\left[x^h / a^h(p,\mathbf{d})\right] + \left(d_k(\mathbf{d}^h)/b^h(p,\mathbf{d})\right) \times \left(\ln\left[x^h / a^h(p,\mathbf{d})\right]\right)^2 \qquad k = 1,\ldots,n \qquad (1)$$

where p_l^h is the price of good *l*, x^h, is household *h*'s total expenditure on the $k = 1,\ldots,n$ grain product groups, **d** is a vector of household characteristics, and $\ln a^h(\cdot)$ and $\ln b^h(\cdot)$ are defined by

$$\ln a^h(p,\mathbf{d}) = \sum_l a_l(\mathbf{d}^h) \ln p_l^h + \frac{1}{2} \sum_k \sum_l g_{kl} \ln p_k^h \ln p_l^h \qquad (2)$$

$$\ln b^h(p,\mathbf{d}) = \sum_{k=1} b_k(\mathbf{d}^h) \ln p_k^h \qquad (3)$$

The household characteristics included in the **d** vector of dummy variables are; a single woman with children, single man with and without children, two adults without children, two adults with one child, two adults with two children, two adults with three or more children, three or more adults, part time worker, student and pensioner. The reference household consists of a full time working single woman without children. A person is considered a child up to the age of 16.

The demand system for the second stage of expenditure allocation has the same functional form as (1), and can be written as

$$s_{(k)i}^h = a_{(k)i}(\mathbf{d}^h) + \sum_j g_{(k)ij} \ln p_{(k)j}^h + b_{(k)i}(\mathbf{d}^h) \times \ln\left[x_k^h / a_k^h(p,\mathbf{d})\right] + \left(d_{(k)i}(\mathbf{d}^h)/b_k^h(p)\right) \times \left(\ln\left[x_k^h / a_k^h(p,\mathbf{d})\right]\right)^2 \qquad i = 1,\ldots,m \qquad (4)$$

where $s_{(k)i}^h$ is household *h*'s budget share for good *i* within group *k*, $p_{(k)j}$ is the price of good *j* in group *k*, and x_k^h is the total expenditures that household *h* has allocated to the goods in group k in the first stage allocation problem. This procedure extends in a natural way to similar sub-demand systems when we have three stage and four stage allocation of expenditures on grain products.

2.2 Econometric Considerations

There is a large number of households in the sample who have not purchased some of the goods during 2003. For example, for fresh filled pasta and fresh unfilled pasta the occurrence of zero expenditure is as high as 92 and 83 percent. The model traditionally used to account for censoring in commodity demand is the Tobit model (Tobin 1958 and Amemiya 1974). However, the underlying assumption in such models[7] is that the same stochastic process determines both the value of continuous observations of the dependent variable and the discrete switch at zero. That is, a zero realisation for the dependent variable represents a corner solution. This clearly restricts other possible determinants of the zero observations, such as potential infrequencies of purchases or misreporting in commodity demand. Such restrictions have been recognised in the past by, for example, Deaton and Irish (1984) and Blundell and Meghir (1987).

Whether the zeros are a result of infrequencies of purchases or a result of non consumption is difficult to say. To allow for infrequencies of purchases, Blundell and Meghir (1987) presented a bivariate alternative to the Tobit model with separate processes determining the censoring rule and the continuous observations. It is also reasonable to assume that there are separate processes determining the zero-one decision of buying a good and the decision of how many units to actually buy. Therefore, to get consistent parameter estimates we follow Heckman’s (1979) two-step procedure and estimate separate probit and truncated regression models for each commodity group.

Following Blundell, Pashardes and Weber (1993), we simplify the simulations by specifying $\ln a^h(p,d)$ as the household specific Stone price index, $\ln P^h = \sum_k s_k^h \ln p_k$, and setting the price aggregator, $\ln b^h(p,d)$, equal to one. The estimated demand system for household h can therefore be written as

[7] i.e., the Tobit1 model, Amemiya (1984).

$$s_k^h = a_k(\mathbf{d}^h) + \sum_l g_{kl} \ln p_l^h + b_k(\mathbf{d}^h) \times \ln[x^h / P^h] + d_k(\mathbf{d}^h) \times \left(\ln\left[x^h / P^h\right]\right)^2 + j_k \hat{l}_k^h + e_k^h \qquad k = 1, \ldots, \mathrm{n} \quad h = 1, \ldots, \mathrm{r} \tag{5}$$

where e_k^h is an error term reflecting unobserved taste variation and *r* denotes the subsample for which $s_k^h > 0$. In addition, $\hat{l}_k^h = f(\hat{y}_k \mathbf{z}_k^h) / \Phi(\hat{y}_k \mathbf{z}_k^h)$ is the estimated inverse Mills ratio, where $f(\cdot)$ and $\Phi(\cdot)$ are the probability density and cumulative distribution functions of the standard normal distribution, with $\hat{y}_k$ estimated in a first step from a univariate probit model for group *k* (see e.g., Leung and Yu 1996). The explanatory variables included in $\mathbf{z}_k$ are the prices of the products in equation *k*, the household income and the same set of dummy variables as those contained in the $\mathbf{d}$ vector. Although the notation in equation (4) refers to the demand for the *k* goods in the first allocation stage, the same procedure has been used in the estimation of all sub demand systems, see Figure 1.

The expenditure system has a set of within-equation and cross-equation restrictions that we impose. These are homogeneity, which gives rise only to within-equation restrictions, and symmetry, which gives rise to cross-equation restrictions. Homogeneity can thus be imposed in a first stage by estimating single equations. Since the number of observations will differ for different goods after the selection of $s_k^h > 0$, we use a minimum distance estimator (see Ferguson 1958) to impose the cross-equation restrictions in a second stage. If estimating the regression system simultaneously, we would loose information, as only households with $s_k^h > 0, \forall k$ would be included in the regression.

Let $\hat{m}$ be a $q \times 1$ vector of unrestricted parameters, and let *q* be a vector of symmetry-restricted parameters of dimension $p \times 1$. Then under the null *q* = *g*($\hat{m}$), where *g* is a known function and *p* ≤ *q*, the symmetry restricted parameter estimates can be obtained by minimising

$$\Psi(q) = [\hat{m} - q]' \begin{bmatrix} \hat{\Sigma}_{m_1} & 0 & 0 \\ 0 & \mathbf{O} & 0 \\ 0 & 0 & \hat{\Sigma}_{m_n} \end{bmatrix}^{-1} [\hat{m} - q] \tag{6}$$

where $\hat{\Sigma}_{m_1}$ is an estimate of the covariance matrix of $\hat{m}_1$, where the subscript *1,…,n* refers to the equation for a specific good within the demand system.[8] The minimised value of $\Psi(q)$ follows a chi-square distribution with degrees of freedom equal to the number of restrictions. The consistency of the minimum distance estimator simply requires that the restrictions are correct and that $\hat{m}$ is a consistent estimator. For the linear case the restrictions simplify to $q = Km$, where K is a $q \times p$ matrix. Instead of specifying a particular form of the heteroscedasticity, we employ White's (1980) approach to calculate the standard errors.

3. Data

To perform the analysis, we use three data sources. To estimate the demand system for grain products, we use market research data from GfK Sweden and household expenditure data (HUT) on bread purchases from Statistics Sweden. We match household purchases with their product contents, by using nutritional information from the SLV nutrition database.

The GfK data is based on weekly diary recordings of grain product purchases. To reduce the prevalence of non-purchases (zeros) in the sample, we aggregate the data to a yearly level.[9] The data contains information on annual retail purchases of bakeries, bread, breakfast cereals, frozen and fresh ready-to-eat food, pasta, rice as well as flours. The information on products purchased by the GfK households is detailed and includes type, price and size of the products bought. An exception here is soft bread, for which the GfK households are only requested to state if they have purchased the product (i.e. "soft bread"), leaving out all other product specific information, with the exception of total expenditures. To gain more information on the type of bread purchased, we therefore use the 1996 household expenditure data (HUT) from Statistics Sweden, which provides information on the amounts of types of bread (white or dark) purchased, as well as a price index for bread prices.

To be able to aggregate the purchases to a yearly level, we need to observe the households purchase for a full year. In the GfK household panel, 1336 households have been in the panel

[8] The minimum distance estimator is just applied to price parameters, meaning that the other parameters in the demand system will not be affected.

[9] Simulation results in Leung and Yu (1996) show that the parameter bias and parameter squared error increases as the degree of censoring increases (i.e., the smaller the proportions of uncensored observations are).

for the full year of 2003 and are hence contained in the sample used for the analysis. The sample of households is satisfyingly representative for the population, even though pensioners are slightly over represented. The sample of households in the data from Statistics Sweden consists of 1104 households.

3.1 Consumption patterns of the average household

Table 3.1 shows descriptive statistics on the budget shares for the sample. Pre-prepared foods is the dominating group of grain consumption, with the average household devoting more than 80 percent of its total grain expenditures to this group, while the rest of the grain budget is fairly evenly allocated between ready-to-eat meals and staple goods for cooking. Bread and breakfast cereals are, in turn, the dominating groups within pre-prepared foods, with 66 percent of total pre-prepared food expenditures for the average household being devoted to bread and 17 percent being allocated to breakfast cereals. Within the bread group, households on average allocate 88 percent of their expenditures to soft bread. Within soft bread, the average household allocates its expenditures fairly evenly over dark and white bread. Since we are not able to single out the Keyhole labelled soft bread, we will use the dark soft bread as a proxy for Keyhole labelled soft bread in the analysis. Noteworthy is that within the hard bread group, Keyhole labelled hard bread is clearly dominating. As for breakfast cereals, most of the expenditures on this group is allocated to flakes and musli.[10]

Insert Table 3.1 here.

[10] It should be noted that the selection of breakfast cereal products into the Keyhole labelled group is based on the 2005 criteria for Keyhole certification (LIVSFS, 2005:9), whereas the expenditure data is from 2003. The 2005 criteria are stricter than those prevailing in 2003 (required minimum levels of fat, salt and sugar are lower, whereas required levels of dietary fibre are higher). For many products, maximum required levels of salt and sugar did not even exist in 2003 (SLVFS ,1989:2). It should therefore be expected that some of the products found in the müsli group did fullfill the 2003 Keyhole criteria, and that today, product contents has been revised so as to fullfill the 2005 criteria. The budget share for Keyhole labelled breakfast cereals is therefore likely to be understated. On the other hand; using dark soft bread as a proxy for Keyhole labelled soft bread in the analysis means that the share of Keyhole labelled soft bread is likely to be overstated, since all dark soft bread is not Keyhole labelled.

3.2 Product characteristics

Food products purchased by the GfK and HUT households are matched with their product contents, by using the information on nutritional values in the nutrient database kept by the SLV. The level of detail in the GfK data allows for matching a product of a specific brand (here called “brand product”) with its product content. The brand products are thereafter divided into somewhat more aggregated products (for example; all dry, white wheat pasta of different brands are aggregated into a product; unfilled pasta). The product content is the weighted average of the contents of the brand products, where the shares of purchases of different brands are used as weights. The nutrient contents that have been matched with the products are energy density (kilo joule per 100 gram product), as well as the density of fat, saturated fat, sugar, added sugar, salt and, fibre, all measured in grams per 100 gram product. For convenience, we will refer to fat, saturated fat, sugar, added sugar and salt as the “unhealthy” nutrients, due to the fact that the average household is likely to over consume these nutrients (see Section 5.1). For underweight individuals an increased intake of these nutrients will be health enhancing, though, salt perhaps being the exception.

Descriptive statistics of the product contents is given by Table 3.2 below.

Insert Table 3.2 here.

As expected, bakery products have the highest energy density of all product groups in the data, but the individual product with the highest energy density turns out to be white wheat hard bread. The highest fat content is found in dough (almost 40 grams per 100 gram), which is mainly due to this product almost exclusively consisting of butter dough. Also cakes, sweet buns and pirogues and pan pizzas contain high amounts of fat per 100 grams (24, 20 and 23 grams per 100 gram, respectively). The product with the highest content of fibre per 100 gram is Keyhole labelled hard bread, with more than 14 grams of fibre per 100 gram product.[11]

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[11] Noteworthy from Table 3.2 is that the product dark hard bread on *average* fullfills the criteria for Keyhole labelling. However, none of the individual products in this product group fullfills these criteria and, hence, they are not included in the Keyhole labelled group.

3.3 Dietary quality of the average household

We measure the quality of the diet with the density of the nutrients in the household diet, i.e. the grams of nutrients per 100 gram product. Descriptive statistics of the dietary quality for the average household is found in column 1 of Table 6.1 below. The density of unhealthy nutrients in the average grain diet, such as fat and sugar, seems to be relatively low. Table 6.1 also shows that the share of Keyhole labelled bread and breakfast cereals, of total bread and breakfast cereals purchased by the average household, amounts to 47 percent, whereas the share of bakeries and ready-to-eat meals, of total grain purchases, amounts to 3 percent.

4. Estimation results

F-tests indicate that the estimates of the parameters of the b and d functions, in the original specification, are not significantly different from zero. We have therefore reduced the number of estimated parameters in the final specification of the model and excluded the household specific parameters from these functions. The final estimation results show the importance of quadratic terms in real expenditures as well as the importance of controlling for non-consumption. In 35 out of 42 cases (and for all of the equations at the lowest level of aggregation, except for white wheat flour and cakes) are the estimated parameters for the non-linear expenditure variable significantly different from zero, at a 5 percent significance level. Using the same significance level, we find that 22 percent of the estimated parameters controlling for censoring and non-consumption (i.e., the variable related to the inverse Mills ratio), are significantly different from zero.

Likelihood ratio tests for homogeneity generally suggest that this restriction cannot be rejected. Chi-square tests indicate that the symmetry restrictions are rejected for only 2 of the 9 estimated demand systems, at a 5 percent significance level. The symmetry restrictions are rejected for the sub demand systems for pasta and bread, with ***P***-values 0.02 and 0.00, respectively. The lowest ***P***-value for the chi-square test for symmetry in the other sub demand systems is 0.18. The adjusted ***R***-square is generally high and lies in the range 0.2 to 0.6. Overall the model fit is found to be good.

The estimation results are, however, most easily summarised by elasticities. Own price elasticities are shown by Table 4.1, and the formulas to calculate these elasticities are found in Appendix B.

Insert Table 4.1 here.

As shown by Table 4.1 all compensated own price elasticities are negative, indicating that the negativity condition is fulfilled. The uncompensated own price elasticities range from -0.21 for whole grain pasta to -1.56 for “others” breakfast cereals. With the exception of filled pasta, the pasta products generally show the lowest price sensitivity. Another group of products that is characterized by relatively low own price elasticities (in absolute value) is the the bakeries group. Furthermore, the results indicate that white wheat hard bread is the product with the highest price sensitivity within the bread group. For Keyhole labelled and dark hard bread, the price sensitivity is lower, with estimated own price elasticities of -0.8 and -0.7, respectively. That the price sensitivity for white wheat hard bread is higher than for other hard bread products, might be a result of this type of hard bread being a closer substitute to soft bread. For the products within breakfast cereals, the own price elasticities are estimated to be around -0.7 (“others” being the exception) and own price elasticities for the products within the rice group vary between -0.5 and -0.9. The products within ready-to-eat meals generally have an own price elasticity of around -0.8. We also calculated cross price elasticities, and, as expected, these are generally much smaller in absolute value than the own price elasticities reported here.

The price elasticities in Table 4.1 are in line with elasticities reported in previous studies (e.g. Chouinard et al., 2006, and Kuchler et al., 2005).

5. Simulations

The empirical model from Section 3.1 is used to illustrate responses of households to non-marginal changes of the value added tax (VAT) on different food products, as well as to excise duties on nutrients in the grain products. The type of model used here is particularly useful for such analyses. A non-marginal tax change, that has a sizeable impact on prices, will affect the households' real income. A demand system of the type used here takes this income effect into account. In addition, the model employed includes non-linear income effects, which may be important when large tax changes are considered. Also, the demand system handles substitution effects, which might be large as a result of the changes in tax rates.

5.1 Policy reforms

In Sweden, the VAT on food is 10.71 percent of the consumer price (or, equivalently, 12 percent on the producer price). Our baseline scenario is, therefore, a 10.71 percent VAT rate on the consumer price of all grain products. We start off by simulating the effects of a reform that is relatively easy to communicate and implement:

(i) a removal of the VAT on Keyhole labelled bread and breakfast cereals, while keeping the VAT on all other grain products at the initial 10.71 percent.

As will be shown, this reform has little impact on the fibre intake, though. We therefore simulate the effect of a more extensive VAT reform, designed to increase the fibre intake of the average household by the recommended 38 percent;

(ii) a 50 percent subsidy of Keyhole labelled bread and breakfast cereals

Instead of subsidizing commodities, policy makers might consider subsidizing the fibre content. To compare effects of VAT and fibre subsidy reforms, we therefore also analyze the effects of a corresponding fibre subsidy, designed to increase the fibre intake of the average household by 38 percent;

(iii) a SEK 0.046 subsidy per gram fibre, in a kilo gram grain product

Thereafter, we will simulate results of funded reforms, i.e. policy packages containing the above subsidies, funded by taxes on unhealthy commodities and nutrients, respectively.[12]

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[12] We also simulated the results of a fibre subsidy reform (a SEK 0.0087 subsidy per gram fibre in a kilo gram grain product) that achieved the same increase in the fibre intake as the reform entailing a removal of the VAT on Keyhole labelled bread and breakfast cereals. However, the impact on the grain diet of such a small fibre subsidy reform turned out to be minor and is therefore not reported here. Worth mentioning, though, is that the qualitative effects on the diet of the average consumer of the small fibre subsidy reform turned out the same as the more extensive fibre reform reported here.

Swedish consumers generally over consume fat (particularly saturated fat), salt and sugar (particularly added sugar). Even though there are no specific recommendations for grain products on the intake of these nutrients, the health of the average consumer is unlikely to improve if the intake of these nutrients increases (be it from grain consumption or consumption of other types of food). Total fat consumption of the average consumer amounts to 33-35 percent of total energy consumed, exceeding the recommended 30 percent of the daily intake. This is mainly due to the intake of saturated fat being higher than recommended (Becker and Pearson, 2002, and SNR, 1997). The average consumption of salt, excluding added table salt to prepared meals, is more than 40 percent above recommended levels for women and almost 80 percent above recommended levels for men. However, it is difficult for consumers to avoid over consumption of salt, since most products available in the Swedish food market contain high levels of salt (SNÖ, 2003). As for added sugar, the intake from the average consumer is right on the recommended level (Becker and Pearson, 2002, and SNR, 2005).

5.2 Simulation model

The simulation method can be described as follows. The percentage price change on good *i* in group *k* is calculated according to the following formula

$$\frac{\Delta p_{(k)i}}{p_{(k)i}^{0}} = \frac{(t_i^1 + t_i^1 + t_i^1 t_i^1) - (t_i^0)}{1 + t_i^0} \qquad (7)$$

where the superscript denotes the tax regime (0 denotes the baseline tax), t is the VAT rate (on the consumer price) for good *i*, and t is the excise duty (or fibre subsidy) on good *i*. It should be noted that t shows the excise duty's share of the producer price (price exclusive of taxes). The price level for household *h* for good *i* in group *k* after the tax change is then equal to

$$p_{(k)i}^{h1} = \left(1 + \frac{\Delta p_{(k)i}^{h}}{p_{(k)i}^{h0}}\right) p_{(k)i}^{h0} \qquad (8)$$

which means that the post-reform Stone price index for group *k* and household *h* equals

$$\ln P_k^{h1} = \sum_i s_{(k)i}^{h} \ln p_{(k)i}^{h1} \tag{9}$$

where, as previously, $s_{(k)i}^{h}$ is household *h*'s initial expenditure share on good *i* in group *k*. In the simulation we do not allow for possible general equilibrium effects, i.e. we assume that taxes are shifted completely on consumer prices.

Substituting the post-reform Stone price indexes into the demand system representing the first-stage budgeting process gives us the new allocation across the different commodity groups for household *h*. The new consumption vector is given by

$$\begin{aligned} s_{(k)}^{h1} &= \hat{a}_{(k)}\mathbf{d}^h + \sum_k \hat{g}_{kl} \ln p_k^{h1} + \hat{b}_{(k)} \ln\left[x^{h0}/P^{h1}\right] \\ &\quad + \hat{d}_{(k)}\left(\ln\left[x^{h0}/P^{h1}\right]\right)^2 + \hat{e}_{(k)}^{h0} \end{aligned} \qquad k = 1,\ldots,\mathrm{n} \tag{10}$$

where a ^ denotes an estimate and $\mathbf{d}^h$ is the vector of household characteristics. The superscript 0 indicates the point of reference (baseline). In the simulations we keep nominal expenditure (*x*) unchanged. The last term in equation (10), $\hat{e}_{(k)}^{h0}$, represents unexplained household-specific effects not accounted for in the estimations, and the effect of non purchase. The latter is assumed to be constant over simulations.

Given the new group shares, according to equation (10), new expenditures on each group will be

$$x_{(k)}^{h1} = s_{(k)}^{h1} x^{h0} \qquad k = 1,\ldots,\mathrm{n} \tag{11}$$

which is substituted into the demand system representing the second stage of the budgeting process. This results in

$$\begin{aligned} s_{(k)i}^{h1} &= \hat{a}_{(k)i}\mathbf{d}^h + \sum_j \hat{g}_{ij} \ln p_{(k)j}^{h1} + \hat{b}_{(k)i} \ln\left[x_{(k)}^{h1}/P_{(k)}^{h1}\right] \\ &\quad + \hat{d}_{(k)i}\left(\ln\left[x_{(k)}^{h1}/P_{(k)}^{h1}\right]\right)^2 + \hat{e}_{(k)i}^{h0} \end{aligned} \qquad i = 1,\ldots,\mathrm{m} \tag{12}$$

In the case of additional sub-groups, or allocation stages, the above procedure is repeated for each allocation stage. From (12) we can define post-reform expenditures x_i^{h1} on good *i* and the volume V_i^{h1} of good *i* as

$$x_i^{h1} = s_{(k)i}^{h1} x_k^{h1} \tag{13a}$$

$$V_i^{h1} = x_i^{h1} / p_{(k)i}^{h1} \tag{13b}$$

The change in the intake of nutrient *q* for household *h*, ΔN_q^h, can then be calculated by

$$\Delta N_q^h = \sum_i w_{iq}^h \left(V_i^{h1} - V_i^{h0} \right) \tag{14}$$

where w_{iq}^h is the content per kilo gram of nutrient *q* (fat, saturated fat, fibre, kilo joule, salt, sugar or added sugar) in product *i*, for household *h*.[13]

Each household's tax payment on product *i*, before and after the tax reform, is calculated as

$$VAT^{h0} = \sum_i t_i^0 x_i^{h0} \tag{15a}$$

$$VAT^{h1} = \sum_i t_i^1 x_i^{h1} \tag{15b}$$

$$T^{h1} = \sum_q \sum_i p_q w_{iq}^h V_i^{h1} \tag{15c}$$

where *VAT* denotes value added tax payment, and *T* the excise duties paid on food products. p_q is the excise duty in SEK per gram of nutrient *q* in each kilo gram grain product.

[13] Note that the content of nutrients of products can differ over households since the calculations of the content is based on the household specific basket of brand products that make up each product in the demand system.

6. Simulation results

In this section, we report on the results from simulating reforms (i)-(iii) in section 5.1. To facilitate, we name reform (i), i.e. the removal of the VAT on Keyhole labelled bread and breakfast cereals, "VAT reform (1)". The more extensive reforms (ii) and (iii), i.e. the VAT and fibre subsidy reforms designed for the average household to attain the recommended 38 percent increase in the fibre intake, are named "VAT reform (2)" and "fibre subsidy reform", respectively.

We start off this section by analyzing the simulated results from the unfunded reforms stated above, and thereafter proceed by analyzing the simulated results of reforms funded by commodity taxes on particularly unhealthy commodities and excise duties on particularly unhealthy nutrients.

We analyze how the policy reforms affect the prices of individual products and the overall price level faced by the average household, calculated as the change in the antilog of Stone's price index. We continue by analyzing the impact the price changes have on diets and public revenues, the latter calculated as the relative change in VAT and excise duty payments on grain products by the average household. Simulation results are driven by the combination of own-price, cross-price and income effects, but also by the nutritional content in the products.

6.1 Effects of unfunded reforms

Table A.1 in Appendix A shows the impact on prices of grain products from implementing the unfunded reforms. Column 1 shows the price changes resulting from VAT reform (1) and columns 2 and 3 show the price changes from VAT reform (2) and its corresponding fibre subsidy reform. Least transparent are price changes due to the fibre subsidy reform. As shown by column 3 in Table A.1, if implementing the fibre subsidy, prices would range from 45 percent of the baseline price (for Keyhole labelled flour).[14]

Comparing columns 2 and 3 in Table A.2, Appendix A, we find that a VAT reform designed to achieve a 38 percent increase in the fibre intake has a greater impact on the price level than

[14] Note also that relative price changes are sizeable for white wheat flour due to the excise duty reforms. This result is due to the price of white wheat flour being low at baseline, i.e. it is not a result of white wheat flour being particularly rich in fibre.

does a fibre subsidy reform that directs the consumption of the average household to the same increase in the fibre intake.

Table 6.1 shows the adjustments of the diet, by the average household, and the resulting relative change in public revenues from grain consumption of the average household, due to these price changes. Column 1 in Table 6.1 shows the baseline, i.e. the composition of the grain diet for the average household before any reform has been implemented and columns 2-4 show the results of the respective policy reforms.

Insert Table 6.1 here.

As shown by the second column (VAT reform (1)), our results imply that removing the VAT on Keyhole labelled bread and breakfast cereals results in the average household achieving the recommendation of half the bread and breakfast cereal consumption being Keyhole labelled. However, the increase in volumes consumed of bread and breakfast cereals is fairly small; 3 percent, which also shows in the moderate increase of fibre consumption, amounting to 4 percent. This suggests that the average household far from attains the recommendation of doubling its bread and breakfast cereal consumption (alternatively increasing the fibre intake by a minimum of 38 percent), should this reform be implemented. In addition, our results suggest that volumes consumed of unhealthy grain products would increase (bakeries and ready-to-eat-meals), although by a modest 1 percent, for the average household. Volumes consumed by the unhealthy nutrients increase by 1-2 percent. The fibre density of the grain diet increases from 3.32 grams per 100 gram to 3.37 grams per 100 gram, for the average household, though, and there are slight decreases in the density of all other (unhealthy) nutrients. Our results also imply that VAT reform (1) would result in a 30 percent decrease of public revenues from VAT on grain products consumed by the average household.

If instead implementing a 50 percent subsidy on Keyhole labelled bread and breakfast cereals (i.e. VAT reform (2)), our results suggest that the share of Keyhole labelled bread and breakfast cereals, out of the total bread and breakfast cereals consumed, rises to almost 70 percent. The share of bakeries and ready-to-eat meals, of total grain consumption, remains the same as before the reform, though. Overall volumes of bread and breakfast cereals would increase by 40 percent, whereas volumes of bakeries and ready-to-eat meals would rise by 6 percent. In addition, the intake of unhealthy nutrients rises substantially, although by less than the fibre intake. The rise in salt and sugar intakes is particularly high; 25 percent. However, the impact on the quality of the diet, as measured by the density of the nutrients, is more mixed. The density of fibre increases to 3.80 grams per 100 gram, to be compared with the 3.32 grams per 100 gram at baseline. The density of kilo joule, salt and sugar also increases, whereas the density of all other nutrients decreases. Finally, the reform turns out to be costly, measured by public revenues lost; revenues from VAT on grain products paid by the average household decrease by 160 percent.

The simulated results from the fibre subsidy reform are given in column 4 in Table 6.1. Our results suggest that the share of Keyhole labelled bread and breakfast cereals increases so that the nutritional recommendation is attained. The increase in the share of bakeries and ready-to-eat meals remains the same as before the reform. Comparing the results in column 3 and 4, noteworthy is that volumes consumed of bread and breakfast cereals would increase by 11 percent from the fibre subsidy reform, which is much less than if the corresponding VAT reform was implemented. Also; volumes of bakeries and ready-to-eat meals would decrease by 4 percent. The rise in the intake of fat, saturated fat, kilo joule and added sugar would be higher than that from VAT reform (2), whereas the rise in the intake of salt and sugar would be lower. The density of kilo joule would increase substantially to 989 kilo joule per 100 gram, whereas the density of salt, sugar and added sugar would decrease substantially. There would only be small changes in the density of fat and saturated fat, compared to the baseline. Compared to VAT reform (2), the fibre subsidy reform is less costly, although still imposes a sizeable burden on public revenues; the VAT and excise duty paid by the average household would decrease by 129 percent.

6.2 Effects of funded reforms

Subsidizing either commodities rich in fibre or the fibre content itself is not only costly, in terms of lost revenue, it also leads to unwanted increases in unhealthy nutrients, as shown by Table 6.1. Governments might therefore consider policy packages that are revenue neutral and at the same time restrict the increase in unhealthy consumption. We therefore also simulate the results from revenue neutral reforms, where the subsidies of Keyhole labelled bread and breakfast cereals are funded by increased commodity taxes on particularly unhealthy grain products; bakeries and ready-to-eat meals (see Table 3.2 for descriptive statistics on product contents). The reform that entails a subsidy on the fibre content is funded by excise duties on other (unhealthy) nutrients. Funding, within the grain consumption demand system, could be done either by taxing one particular nutrient, or a combination of unhealthy nutrients. Here, we focus on analyzing tax schemes entailing a subsidy on fibre, funded by an excise duty one single unhealthy nutrient; fat, saturated fat, sugars or added sugars.[15]

Our results imply that removing the VAT on Keyhole labelled bread and breakfast cereals could be funded by a 34.2 percent VAT on bakeries and ready-to-eat meals. The more extensive subsidy of Keyhole labelled bread and breakfast cereals would require a VAT on bakeries and ready-to-eat meals as high as 113.8 percent.

Funding the small VAT reform by a 34.2 percent VAT on bakeries and ready-to-eat meals results in the price of these products increasing by 21 percent, compared to baseline. For the same products, the price increases by 93 percent, if funding the more sizeable VAT reform (by imposing a VAT of 113.8 percent on bakeries and ready-to-eat meals). For all other products, individual price changes are the same as in columns 1 and 2 in Table A.1, should funded VAT reforms be implemented.

Table A.2 shows the change in the overall price level of the average household due to selected funded reforms. Our results imply, for instance, that the overall price level for the average household slightly decreases, to 99 percent of the baseline price level, if the VAT on Keyhole labelled bread and breakfast cereals is removed and the VAT on bakeries and ready-to-eat meals is raised to 34.2 percent. The more extensive funded VAT reform results in the price level faced by the average household decreasing to 97 percent of the baseline price level.

The changes in consumption and public revenues, resulting from the individual and overall price changes from these revenue neutral policy packages, are shown in columns 1 and 2 of Table 6.2. Our results imply that both revenue neutral VAT-reforms result in the average household attaining the nutrition recommendation of half of bread and breakfast cereals consumed being Keyhole labelled; the more extensive funded reform even leads to almost 70 percent of bread and breakfast cereals consumed by the average household being Keyhole

[15] As noted earlier in this paper, salt is also over consumed by the average consumer. However, salt is less efficient to tax for the time being, since food is generally high in salt and substitutes for consumers therefore few, if looking for alternatives less rich in salt (SNÖ, 2005). We therefore choose not to simulate the result of reforms entailing an excise duty on salt.

labelled, should the reform be implemented. These results are very similar to the simulated impact on diets of the unfunded VAT reforms.

Insert Table 6.2 here.

Our results also indicate that the smaller funded VAT reform results in an increase in volumes consumed of bread and breakfast cereals, as well as the intake of fibre, amounting to 3 percent. The change in other nutrients is minor.

The extensive funded VAT reform greatly increases the volumes consumed of bread and breakfast cereals by the average household by as much as 38 percent (i.e. by only two percentage points less than the unfunded reform) whereas volumes of bakeries and ready-to-eat meals decrease by 10 percent. The substantial increase in volumes consumed resulting from the VAT reform is also reflected in the high increase of the fibre intake; 35 percent, not far from the recommended increase of 38 percent, which was attained when simulating the results from the corresponding unfunded reform. However, increases of other, unhealthy, nutrients are still sizeable, although less so than if imposing the unfunded VAT reform, amounting to more than 20 percent for salt and sugar.

The impact on the quality of the grain diet, as measured by the density of nutrients in the grain diet, is mixed. Comparing the densities in columns 1 and 2 in Table 6.2 with the densities at baseline (see Table 3.3), it is noteworthy that the density of fibre increases from both reforms, whereas the density of fat, saturated fat and added sugar decreases from both reforms. The change in the densities is more pronounced if imposing the more extensive VAT reform. Interestingly, the density of sugar, salt and kilo joule also decreases if implementing the smaller VAT-reform, whereas these densities are either unchanged or increase, probably due to a larger income effect would the more extensive reform be imposed. Compared to the unfunded VAT-reforms (see Table 6.1), densities of fibre and kilo joule are higher if implementing funded reforms, whereas densities of all other nutrients are lower.

Table A.3 shows the price changes of revenue neutral policy packages entailing the SEK 0.046 subsidy per gram fibre. The SEK 0.046 subsidy per gram fibre could be funded either by an excise duty of SEK 0.074 per gram fat, an excise duty of SEK 0.325 per gram saturated fat, an excise duty of SEK 0.063 per gram sugar or an excise duty of SEK 0.182 per gram added sugar. As expected, an excise duty per gram saturated fat or added sugar has to be higher than those of fat and sugar, respectively, in order to be part of a revenue neutral policy package, since the content of saturated fat is lower than that of (total) fat and the content of added sugar is lower than that of (total) sugar.

As shown by Table A.3, the funded fibre subsidy reform results in sizeable price changes for many products and most prices are affected, even prices of products that are low in fat or sugar. As might be expected, prices of bakeries are highly affected by fibre subsidies funded by excise duties on fat or sugar. Prices on ready-to-eat meals are also highly affected by reforms funded by excise duties on fat and saturated fat, but almost unchanged by reforms funded by excise duties on sugar or added sugar. Also, the price of fresh filled pasta more than doubles from the reform funded by an excise duty on saturated fat, whereas the price of the same product even decreases (although slightly) if the reform is instead funded by an excise duty on added sugar. As for prices of bread and breakfast cereals in particular, the price of dark soft bread decreases if reforms are funded by excise duties on fat, saturated fat or added sugar, whereas it increases slightly if the reform is funded by an excise duty on added sugar. The opposite is true for the price of white bread. Noteworthy is that the price of sweet breakfast cereals and other breakfast cereals more than doubles from a reform funded by an excise duty on added sugar, compared to baseline. The price of flakes decreases slightly from reforms funded by excise duties on fat or saturated fat, whereas the price of flakes increases sizeably by reforms funded by excise duties on sugar or added sugar. The decrease in the price of Keyhole labelled breakfast cereals is the largest from funding the reform by an excise duty on sugar, whereas the decrease is the smallest if the reform is instead funded by an excise duty on fat or added sugar. Regarding the change in the overall price level due to the funded fibre subsidy reform, Table A.2 shows that the SEK 0.046 subsidy per gram fibre, per kilo gram grain product, coupled with a SEK 0.182 excise duty on added sugar, results in a 4 percent increase in the overall price level, compared to baseline, whereas the same subsidy on fibre financed by a SEK 0.325 excise duty on saturated fat increases the price level by 2 percent. Compared to the average inflation rate over the last decade, these increases are fairly sizeable.

Columns 2-5 of Table 6.3 show how these price changes affect consumption. Our results imply that all revenue neutral reforms lead to the average household attaining the nutrition recommendation of half of bread and breakfast cereal consumption being Keyhole labelled; the policy package entailing the subsidy on fibre combined with an excise duty on added sugar leading to the highest share of Keyhole labelled bread and breakfast cereals, 54 percent. As expected, the resulting increase in volumes consumed is lower from the revenue neutral reforms than from the unfunded fibre subsidy reform, shown in column 1 of Table 6.3. Noteworthy is that a revenue neutral policy package where the fibre subsidy is funded by an SEK 0.182 excise duty per gram added sugar increases the fibre intake of the average household by twice as much as the revenue neutral policy package where the fibre subsidy is funded by an excise duty of SEK 0.074 per gram fat. The former policy package also results in an increase of fat and kilo joule for the average household that is greater than for any other policy package shown in Table 6.3, but, on the other hand, it also leads to sizeable decreases in the intake of sugar and added sugar in particular. As for the densities of the nutrients, the reforms resulting in the highest density of fibre in the grain diet of the average household are the reforms funded by the excise duty on saturated fat and sugar, as shown by column 3 and 4 in Table 6.3. The reform funded by an excise duty on grams of saturated fat also reduces the intake of saturated fat by 3 percent, while being more efficient in increasing the fibre intake than for example the reform funded by an excise duty on gram of fat per kilo gram product. However, the reform entailing the excise duty on added sugar results in the lowest density of salt, sugar and added sugar, and together with the reform funded by an excise duty on saturated fat, it also results in the lowest density of fat and saturated fat.

Insert Table 6.3 here.

7. Conclusions

In this paper, we simulate the results of economic policy reforms designed to improve the quality of the modern grain diet. The policy objectives guiding our analysis are nutritional recommendations for grain consumption given by the Swedish National Food Administration (SLV). For the average consumer, the SLV recommends bread and breakfast cereal consumption to double, while ensuring that half of bread and breakfast cereals consumed are labelled with the “Keyhole” symbol (a healthy label certified by the SLV, based on criteria for the fat, fibre, salt and sugar content of these products). Such changes of the bread and breakfast cereal consumption would contribute to achieving the overall objective of increasing the fibre intake by 38 percent. In addition, recommendations for all food consumption, state that the average Swedish consumer should cut down on fat, especially saturated fat, and salt, while not increasing the added sugar consumption.

The average household is already close to attaining the recommendation of half of bread and breakfast cereals being Keyhole labelled, meaning that this is the easiest recommendation to attain. Our results suggest that a relatively small reform – for instance a removal of the VAT on Keyhole labelled bread and breakfast cereals - results in the average consumer attaining this recommendation. However, the associated increase in the fibre intake is very modest.

Large price changes are needed in order for the average household to attain the recommended increase in the fibre intake (or volumes) for grain consumption. For instance, to attain a 38 percent increase in the fibre intake, our results imply that a commodity subsidy of 50 percent on Keyhole labelled bread and breakfast is needed. Our results also imply that the same increase in the fibre intake is more cost-efficiently achieved by a subsidy of the fibre content, instead of subsidizing products rich in fibre, even if both types of reforms are costly.

In addition, subsidizing products rich in fibre, or the fibre content, seems to lead to unwanted increases in nutrients that are likely to be over consumed by the average consumer (fat, saturated fat, salt, sugar and added sugar), due to the income and substitution effects resulting from the reforms. This is in line with results found by Smed et al. (2007). A healthy diet might, therefore, be better achieved by reforms where subsidies of fibre, or products rich in fibre, are funded by taxes on less healthy commodities or nutrients. Our results imply that in order to fund the 50 percent subsidy of Keyhole labelled bread and breakfast cereals, the VAT on bakeries and ready-to-eat meals has to be substantial, though, closing in on the Swedish VAT on tobacco. The increase in the fibre intake from such a funded VAT reform is substantial. However, increases in other (unhealthy) nutrients are still sizeable, even if reduced, compared to the reform with the unfunded subsidy.

We find that funding a subsidy on the fibre content (i.e. a subsidy per gram fibre in each kilo gram grain product) by either an excise duty on added sugar or on saturated fat, has a good impact on the dietary quality of the average household; the increase in the fibre intake is less than it would be if an unfunded fibre subsidy was imposed, but the funded fibre subsidy reform also efficiently reduces the increase in the less healthy nutrients that results from the unfunded reform.

Finally, this study has limitations that are important to address in future research. First, we assume that taxes are completely shifted on consumers. The supply side of the food market is, however, likely to absorb some of the change in the tax rate, which is not considered here. Therefore, it would also be of interest to study the effects of the tax changes within a general equilibrium framework. In addition, we do not consider administrative burdens of the different tax schemes analyzed, and excise duties on nutrients are likely to be cumbersome to implement. Second, the tax schemes most efficient in directing the consumption of the average household towards healthier levels are likely to affect consumer groups differently. There might be consumer groups that deserve special attention by policy makers, such as low-income earners or families with children. Analyzing the impact over consumer groups of the policy reforms studied here is an important issue that is left for future research.

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Appendix A

Table A.1. Comparing average relative price changes after selected, unfunded, policy reforms

	POLICY REFORM		
	VAT reform(1)	VAT reform(2)	Fibre subsidy reform
Prices on bakeries			
Cakes	1.00	1.00	0.98
Sweet buns	1.00	1.00	0.98
Sweet pies	1.00	1.00	0.99
Prices on bread			
Hard bread			
Keyhole labelled	0.90	0.50	0.75
White wheat	1.00	1.00	0.93
Dark	1.00	1.00	0.88
Soft bread			
Dark	0.90	0.50	0.93
White	1.00	1.00	0.96
Prices on breakfast cereals			
Flakes	1.00	1.00	0.95
Keyhole labelled	0.90	0.50	0.81
Müsli	1.00	1.00	0.83
Sweet cereals	1.00	1.00	0.97
Others	1.00	1.00	0.97
Prices on staple goods for cooking			
Dark flour	1.00	1.00	0.51
Flour for sauces	1.00	1.00	0.94
Keyhole labelled flour	1.00	1.00	0.45
White wheat flour	1.00	1.00	0.53
Dough	1.00	1.00	0.98
Prices on pasta			
Fresh filled	1.00	1.00	0.96
Fresh unfilled	1.00	1.00	0.98
Filled	1.00	1.00	0.98
Unfilled	1.00	1.00	0.95
Whole grain	1.00	1.00	0.93
Prices on ready-to-eat meals			
Pancakes	1.00	1.00	0.99
Pirogues, pan pizza	1.00	1.00	0.99
Pizza, pasta, lasagne	1.00	1.00	0.99
Spring rolls	1.00	1.00	0.99
Others	1.00	1.00	0.99
Prices on rice			
Fast	1.00	1.00	0.99
Fibre	1.00	1.00	0.98
White	1.00	1.00	0.98
Others	1.00	1.00	0.96

Table A.2. Price changes for the average household, from selected policy reforms

Unfunded reforms	
VAT reform(1)	0.97
VAT reform(2)	0.85
Fibre subsidy reform	0.90
Funded reforms	
VAT reform(1)F	0.99
VAT reform(2)F	0.97
Fibre subsidy reform (a)F	1.04
Fibre subsidy reform (b)F	1.02

Table A.3. The impact on prices of funded reforms entailing a fibre subsidy of SEK 0.0460 per gram fibre

	Unfunded	Funding the 0.0460 subsidy per gram fibre by imposing an excise duty of			
		0.0740 SEK per gram fat	0.3250 SEK per gram saturated fat	0.0630 SEK per gram sugar	0.1820 SEK per gram added sugar
Prices on bakeries					
Cakes	0.98	1.25	1.29	1.24	1.64
Sweet buns	0.98	1.26	1.48	1.12	1.20
Sweet pies	0.99	1.17	1.36	1.19	1.44
Prices on bread					
Hard bread					
Keyhole labelled	0.75	0.82	0.80	0.79	0.79
White wheat	0.93	1.09	1.09	1.01	0.95
Dark	0.88	0.95	0.95	0.93	0.89
Soft bread					
Dark	0.93	0.98	0.97	1.02	0.94
White	0.96	1.03	1.02	1.02	0.97
Prices on breakfast cereals					
Flakes	0.95	0.99	0.98	1.18	1.41
Keyhole labelled	0.81	0.93	0.89	0.87	0.93
Müsli	0.83	1.08	1.25	1.36	1.77
Sweet cereals	0.97	0.99	0.99	1.55	2.20
Others	0.97	0.99	0.99	1.55	2.22
Prices on staple goods for cooking					
Dark flour	0.51	0.90	0.72	0.92	0.75
Flour for sauces	0.94	0.96	0.95	0.97	0.98
Keyhole labelled flour	0.45	0.72	0.62	0.54	0.61
White wheat flour	0.53	0.92	0.77	0.80	0.69
Dough	0.98	1.74	2.41	1.00	0.99
Prices on pasta					
Fresh filled	0.96	1.61	2.23	1.02	0.99
Fresh unfilled	0.98	1.01	1.02	0.99	0.98
Filled	0.98	1.22	1.36	1.01	1.00
Unfilled	0.95	0.99	0.96	0.96	0.97
Whole grain	0.93	0.95	0.94	0.94	0.94
Prices on ready-to-eat meals					
Pancakes	0.99	1.13	1.25	1.05	0.99
Pirogues, pan pizza	0.99	1.31	1.60	1.01	1.00
Pizza, pasta, lasagne	0.99	1.11	1.21	1.01	1.00
Spring rolls	0.99	1.15	1.19	1.03	1.00
Others	0.99	1.18	1.36	1.01	1.00
Prices on rice					
Fast	0.99	1.00	1.00	1.00	1.01
Fibre	0.98	1.00	1.00	0.99	1.00
White	0.98	1.00	1.01	0.99	1.00
Others	0.96	1.01	1.02	0.98	1.01

Appendix B

For each person or household the uncompensated price elasticity for a product within each separate demand system is given by

$$e_{fg} = g_{fg} / s_f - (b_f + 2d_f \ln m) \times (s_f / s_g) - k_{fg} \tag{B.1}$$

where $k_{fg} = 1$ if $f = g$ and $k_{fg} = 0$ if $f \neq g$, and m is real expenditures. To simplify the expressions, the household index is suppressed. The expenditure elasticity is

$$E_f = (b_f + 2d_f \ln m) / s_f + 1 \tag{B.2}$$

With positive b and negative d, equation (B.2) shows that the expenditure elasticity may exceed one for households with low expenditures on the goods, indicating that it is a luxury good, whereas households with higher expenditures may have an expenditure elasticity less than one, thereby considering the product to be a necessary good. To calculate the set of compensated elasticities we use the Slutsky equation $e^c_{fg} = e_{fg} + s_g E_f$. In the case of two stage budgeting the total uncompensated price elasticity is given by (Edgerton 1997)

$$e_{ij} = k_{kl} e^c_{(k)ij} + E_{(k)i} s_{(l)j} e_{(k)(l)} \tag{B.3}$$

where $e^c_{(k)ij}$ is the compensated price elasticity between good *i* and *j* in the *k*'th group, $E_{(k)i}$ is the expenditure elasticity for good *i* in the *k*'th group and $e_{(k)(l)}$ is the uncompensated price elasticity between good *k* and *l* at the first allocation stage. The total expenditure elasticity is

$$E_i = E_{(k)} E_{(k)i} \tag{B.4}$$

where E_k is the expenditure elasticity for the k'th group at the first allocation stage. If we extend the analysis to three stage budgeting the expression for the uncompensated price elasticity becomes

$$\begin{aligned} e_{ij} = {} & k_{ab} k_{kl} e^{c}_{[a](k)ij} + k_{ab} s_{[b](l)j} E_{[a](k)i} e^{c}_{[a](k)(l)} \\ & + s_{[b](l)j} s_{[b](l)} E_{[a](k)i} E_{[a](k)} e_{[a][b]} \end{aligned} \tag{B.5}$$

where the notation $[a][b]$ refers to the first allocation stage, and $(k)(l)$ to the second allocation stage. The total expenditure elasticity is given by

$$E_i = E_{[a]} E_{[a](k)} E_{[a](k)i} \,. \tag{B.6}$$

Tables

Table 3.1. Budget shares of the average household, at different allocation steps

Group	Product	Budget share	Group	Product	Budget share	Group	Product	Budget share
First allocation stage			*Third allocation stage*			*Fourth allocation stage*		
Grain purchases	Pre-prepared foods	0.839	*Bakeries*	Cakes	0.734	*Hard bread*	Keyhole labelled	0.786
	Staple goods for cooking	0.079		Sweet buns	0.176		White wheat	0.193
	Ready-to-eat meals	0.082		Sweet pies	0.090		Dark	0.021
	Sum	1.000		*Sum*	1.000		*Sum*	1.000
Second allocation stage								
Pre-prepared foods	Bakeries	0.024	*Breakfast Cereals*	Flakes	0.411	*Soft Bread*	Dark	0.483
	Bread	0.657		Müsli	0.362		White	0.517
	Breakfast cereals	0.173		Keyhole labelled	0.035		*Sum*	1.000
	Pasta	0.079		Sweet cereals	0.141			
	Rice	0.067		Others	0.050			
	Sum	1.000		*Sum*	1.000			
Staple goods for cooking	Dark flour	0.085	*Pasta*	Unfilled	0.853			
	Flour for sauces	0.133		Fresh unfilled	0.084			
	Keyhole labelled flour	0.070		Whole grain	0.010			
	White wheat flour	0.679		Fresh filled	0.030			
	Dough	0.033		Filled	0.024			
	Sum	1.000		*Sum*	1.000			
Ready-to-eat meals	Pancakes	0.073	*Rice*	Fast	0.078			
	Pirogues [a]	0.236		Fibre	0.066			
	Pizza [b]	0.556		White	0.681			
	Spring rolls	0.076		Others	0.175			
	Others	0.060						
	Sum	1.000		*Sum*	1.000			
			Bread	Hard bread	0.119			
				Soft bread	0.881			
				Sum	1.000			

Note: [a] The group pirogues also contains pan pizza. [b] The group pizza also contains pasta and lasagne.

Table 3.2. The average nutritional content in product groups, per 100 gram product

	KJ	Total fat	Saturated fat	Sugar	Added sugar	Salt	Fibre
Bakeries							
Cakes	1631.71	24.29	6.33	27.89	25.35	164.26	2.25
Sweet buns	1633.77	20.12	8.23	11.64	6.32	267.47	2.12
Sweet pies	1084.16	13.62	6.21	17.23	13.45	133.76	1.60
Bread							
Hard bread							
Keyhole labelled	1359.82	2.61	0.38	1.73	0.43	470.20	14.29
White wheat	1636.54	7.41	1.79	4.52	0.42	417.19	5.38
Dark	1425.18	3.98	0.99	3.56	0.29	540.53	11.78
Soft bread							
Dark	1025.82	3.07	0.55	6.03	0.31	358.77	6.47
White	1160.12	4.11	0.81	4.07	0.21	404.35	3.62
Breakfast cereals							
Flakes	1568.93	1.95	0.35	13.46	10.12	895.30	4.23
Keyhole labelled	1448.28	3.67	0.51	2.65	1.73	199.00	9.88
Müsli	1578.77	9.26	3.41	23.37	15.14	256.96	10.80
Sweet cereals	1614.75	1.26	0.25	38.39	28.86	467.08	2.56
Others	1567.01	4.30	1.24	21.44	16.60	368.64	6.21
Flours & dough							
Dark flour	1417.67	2.33	0.28	2.74	0.43	2.64	4.62
Flour for sauces	1407.06	0.69	0.09	1.13	0.51	4.48	3.03
Keyhole labelled flour	1344.52	3.33	0.48	1.24	0.65	3.41	10.89
White wheat flour	1504.68	1.88	0.26	1.53	0.26	0.80	3.60
Dough	2340.20	39.51	17.08	1.10	0.12	309.44	1.60
Pasta							
Fresh filled	708.24	9.15	4.07	0.98	0.14	522.37	0.83
Fresh unfilled	877.06	1.61	0.42	1.01	0.10	297.63	1.78
Filled	767.16	9.90	4.38	1.03	0.18	569.30	1.03
Unfilled	528.50	0.50	0.05	0.20	0.10	1.00	1.12
Whole grain	473.30	0.52	0.06	0.17	0.10	0.10	3.04
Ready-to-eat meals							
Pancakes	807.95	8.81	3.73	4.37	0.01	331.15	0.77
Pirogues, pan pizza	1541.16	23.43	10.11	1.82	0.31	533.81	1.36
Pizza, pasta, lasagne	910.06	9.73	4.14	2.20	0.20	472.06	1.43
Spring rolls	896.20	10.80	2.94	2.80	0.20	510.00	1.20
Others	1024.73	13.26	5.88	2.07	0.25	462.82	1.36
Rice							
Fast	490.91	0.30	0.07	0.32	0.28	270.07	0.50
Fibre	443.54	0.70	0.18	0.49	0.32	2.62	1.12
White	515.25	0.34	0.10	0.15	0.15	307.07	0.48
Others	520.56	0.29	0.10	0.09	0.11	171.77	0.36

Table 4.1. Compensated and uncompensated own price elasticities and expenditure elasticities

	Uncompensated price elasticity	Compensated price elasticity	Expenditure elasticity
Bakeries			
Cakes	-0.56	-0.53	0.46
Sweet buns	-0.64	-0.63	0.29
Sweet pies	-0.58	-0.57	0.19
Bread			
Hard bread			
Keyhole labelled	-0.80	-0.77	0.27
White wheat	-1.27	-1.26	0.18
Dark	-0.72	-0.72	0.15
Soft bread			
Dark	-0.99	-0.83	0.64
White	-0.95	-0.81	0.58
Breakfast cereals			
Flakes	-0.71	-0.62	1.01
Keyhole labelled	-0.70	-0.68	0.60
Müsli	-0.73	-0.63	1.16
Sweet cereals	-0.71	-0.65	0.83
Others	-1.56	-1.53	0.81
Flours & dough			
Dark flours	-0.84	-0.82	1.12
Flours for sauces	-0.49	-0.47	0.68
Keyhole labelled flours	-0.79	-0.77	0.93
White wheat flours	-0.95	-0.87	1.45
Dough	-0.37	-0.35	0.83
Pasta			
Fresh filled pasta	-0.43	-0.42	0.65
Fresh unfilled pasta	-0.74	-0.73	0.60
Filled pasta	-1.50	-1.50	0.13
Unfilled pasta	-0.60	-0.54	1.05
Whole grain pasta	-0.21	-0.20	0.58
Ready-to-eat meals			
Pancakes	-0.78	-0.75	0.42
Pirogues	-0.86	-0.81	0.70
Pizzas	-0.70	-0.62	0.69
Spring rolls	-0.89	-0.87	0.38
Others	-0.26	-0.24	0.43
Rice			
Fast	-0.87	-0.85	0.67
Fibre	-0.50	-0.49	0.52
White	-0.68	-0.64	0.84
Others	-0.85	-0.84	0.44

Table 6.1. Impact on the average household of simulated policy reforms

		Policy reform		
	Baseline	VAT reform(1)	VAT reform(2)	Fibre subsidy reform
Share of Keyhole labelled bread and breakfast cereals	0.47	0.50	0.69	0.51
Share of bakeries and ready-to-eat meals	0.03	0.03	0.03	0.03
Relative change of volumes and intake of nutrients				
Volumes of bread and breakfast cereals		0.03	0.40	0.11
Volumes of bakeries and ready-to-eat meals		0.01	0.06	-0.04
Fibre		0.04	0.38	0.38
Fat		0.02	0.18	0.26
Saturated fat		0.01	0.13	0.20
Kilo joule		0.02	0.20	0.32
Salt		0.02	0.25	0.09
Sugar		0.02	0.25	0.19
Added sugar		0.01	0.12	0.19
Density of nutrients in the grain diet				
Fibre/100 gr grain purchases	3.32	3.37	3.80	3.62
Fat/100 gr grain purchases	2.25	2.23	2.17	2.24
Saturated fat/100 gr grain purchase	0.55	0.54	0.50	0.52
Kilo joule/100 gr grain purchases	936.56	935.59	937.52	988.67
Salt in mg/100 gr grain purchases	190.67	190.13	196.05	175.54
Sugars/100 gr grain purchase	2.86	2.85	2.87	2.74
Added sugars/100 gr grain purchases	1.12	1.10	0.97	1.06
Effects on public revenues				
Average relative change in VAT and excise duty paid in SEK		-0.30	-1.60	-1.29

Note: VAT reform (1) means imposing zero VAT on Keyhole labelled bread and breakfast cereals. VAT reform (2) means imposing the 50 percent subsidy of Keyhole labelled bread and breakfast cereals. Fibre subsidy reform means imposing a subsidy per gram fibre, in a kilo gram grain product, of SEK 0.046.

Table 6.2. The impact on the average household of funded VAT-reforms

	Policy reform	
	VAT reform(1)F	VAT reform(2)F
Share of Keyhole labelled bread and breakfast cereals	0.50	0.69
Share of bakeries and ready-to-eat meals	0.03	0.02
Relative change of volumes and intake of nutrients		
Volumes of bread and breakfast cereals	0.03	0.38
Volumes of bakeries and ready-to-eat meals	-0.01	-0.10
Fibre	0.03	0.35
Fat	0.00	0.12
Saturated fat	-0.01	0.05
Kilo joule	0.01	0.17
Salt	0.01	0.21
Sugar	0.01	0.21
Added sugar	0.00	0.07
Density of nutrients in the grain diet		
Fibre/100 gr grain purchases	3.38	3.84
Fat/100 gr grain purchases	2.20	2.09
Saturated fat/100 gr grain purchase	0.53	0.46
Kilo joule/100 gr grain purchases	935.69	937.40
Salt in mg/100 gr grain purchases	189.72	195.25
Sugars/100 gr grain purchase	2.84	2.86
Added sugars/100 gr grain purchases	1.09	0.95
Effects on public revenues		
Average relative change in VAT and excise duty paid in SEK	0.00	0.00

Note: VAT reform (1)F is the removal of the VAT on Keyhole labelled bread and breakfast cereals funded by a 34.2 percent VAT on bakeries and ready-to-eat meals. VAT reform (2)F is the 50 percent subsidy of Keyhole labelled bread and breakfast cereals funded by a 113.8 percent VAT on bakeries and ready-to-eat meals.

Table 6.3. Impact on the average household from funding the fibre subsidy reform

	Unfunded	Funding the SEK 0.046 subsidy per gram fibre by imposing an excise duty of			
		SEK 0.074 per gram fat	SEK 0.325 per gram saturated fat	SEK 0.063 per gram sugar	SEK 0.182 per gram added sugar
Share of Keyhole labelled bread and breakfast cereals	0.51	0.51	0.52	0.52	0.54
Share of bakeries and ready-to-eat meals	0.03	0.03	0.02	0.03	0.03
Relative change of volumes and intake of nutrients					
Volumes of bread and breakfast cereals	0.11	0.04	0.04	0.03	0.03
Volumes of bakeries and ready-to-eat meals	-0.04	-0.03	-0.06	-0.05	-0.10
Fibre	0.38	0.07	0.11	0.12	0.15
Fat	0.26	-0.01	0.01	0.03	0.05
Saturated fat	0.20	-0.03	-0.03	-0.01	0.00
Kilo joule	0.32	0.02	0.05	0.06	0.10
Salt	0.09	0.02	0.02	0.02	0.01
Sugar	0.19	-0.01	0.00	-0.04	-0.04
Added sugar	0.19	-0.01	-0.01	-0.06	-0.11
Density of nutrients in the grain diet					
Fibre/100 gr grain purchases	3.62	3.55	3.59	3.59	3.53
Fat/100 gr grain purchases	2.24	2.20	2.17	2.21	2.17
Saturated fat/100 gr grain purchase	0.52	0.52	0.50	0.52	0.50
Kilo joule/100 gr grain purchases	988.67	948.73	961.69	953.55	957.97
Salt in mg/100 gr grain purchases	175.54	194.18	191.22	189.00	182.48
Sugars/100 gr grain purchase	2.74	2.81	2.75	2.57	2.44
Added sugars/100 gr grain purchases	1.06	1.09	1.05	0.94	0.82
Effects on public revenues					
Average relative change in VAT and excise duty paid in SEK	-1.29	0.00	0.00	0.00	0.00