DIFFERENTIATED FOOD TAXES AS A TOOL IN HEALTH AND NUTRITION POLICY

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Abstract
The purpose of the present study is to analyse the effects of using economic policy tools in nutrition policy, e.g. introduction of specific taxes on unhealthy food components or differentiated VAT on foods. The effects of such regulation instruments are demonstrated using Denmark as an illustrative case. A model concept combining econometric models of food consumption behaviour for different socio-demographic groups with a model for conversion between food consumption and nutrient intake is developed. The socio-demographic effects of four different tax or subsidy regulation schemes are investigated.

Keywords: obesity, food taxes, econometric model, socio-demographic differences

1. Introduction

It is half a century since obesity[i] was introduced into the international classification of diseases. Today there are globally more than 1 billion overweight adults and at least 300 million of them are obese. These numbers include 17.6 million children under five who are estimated to be overweight (WHO, 2003). Although obesity should be considered a disease in its own right it is also one of the key determinants for other chronic diseases together with smoking. Overweight and obesity lead to adverse metabolic effects on blood pressure, cholesterol, triglycerides and insulin resistance. The nonfatal, but debilitating health problems associated with obesity includes respiratory difficulties, chronic musculoskeletal problems and infertility. The more life threatening problems fall into four main areas; cardiovascular disease problems; problems associated with insulin resistance such as type 2 diabetes; certain types of cancer, especially the hormonally related and large-bowel cancers; and gallbladder disease. Obesity accounts for 2-6 per cent of total health care costs in several developed countries. The true costs are undoubtedly much greater as not all obesity related costs are included in the health care cost calculations (WHO, 2003).

In part due to rising income and more urban population, diets high in complex carbohydrates have been replaced by diets with a higher proportion of saturated fats and sugars. At the same time, large shifts towards less physically demanding work, increasing use of automated transport and technology at home has been observed worldwide (WHO, 2003). From an economic perspective, there are several suggestions to what drives this shift in diet. These are ranging from technological change and thereby lowered food prices (Cutler *et al*., 2003, Lakdawalla and Philipson, 2003) to increased frequency of foods eaten away from home, decline in the number of smokers and increased participation in the labour force by women (Chou *et al*., 2003, Anderson *et al*., 2003). In general the studies conclude that the price of foods, although not systematically perceived as a barrier to healthy eating, is an important determinant of food choice. This is especially the case among low-income groups, lower social classes and unemployed people (Darmon *et.al,* 2002*;* Lennernas *et al,* 1997; Glanz *et al*., 1998).

Effective action to avoid the obesity epidemic has not yet been implemented. A preferred strategy in many countries is to promote a healthy lifestyle through information campaigns, etc. Such health promotion strategies rely on individuals to respond to this information on a voluntary basis and they have had only moderate effects (International Obesity Task Force, 2003). An alternative to the provision of health information might be to provide food consumers with economic incentives to choose a healthy diet, for instance by making the healthier foods cheaper relative to the less healthy foods. The purpose of the present study is to analyse the effects of using such economic incentive-based policy tools in nutrition policy. Approaches to this might include the introduction of specific taxes on unhealthy food components (e.g. saturated fats, sugar), or differentiating existing Value Added Taxes (VAT) on foods, lowering the VAT on healthy foods and increasing the VAT on less healthy foods. The effects of taxes on unhealthy food components and subsidies on healthy food components are demonstrated quantitatively using Denmark as an illustrative case.

The paper is organised as follows. After a description of the health and nutrition status in Denmark, the methodological framework is outlined in section 3. Three different incentive-based regulation schemes are presented in section 4, and their effects on food consumption and nutrient intake are analysed in section 5. Finally, section 6 draws some conclusions, policy implications and suggestions for further research.

2. Trends in Danish obesity problems and food intake

The extent of the obesity problem in Denmark is quite similar to that in most other European countries (OECD, 2004). Almost 10 per cent of the adult population could be characterised as obese in 2000, and this figure is similar for many other countries, however with a few exceptions. With an increase from around 6 per cent in the late 1980's, Denmark is also fairly representative with regard to the development in average obesity rate. The average obesity rate covers significant differences among socio-demographic groupings of the population. Hence, the frequency of obesity is considerably higher in groups with short educations, low incomes and unskilled work and groups residing in rural areas. The growth in obesity rate is relatively strong among the younger and among groups with short education (Richelsen *et al.,* 2003, Nichele, 2004). As mentioned in the introduction, there may be two overall reasons for the growth in obesity: higher intake of calories or less physical activity – or both. Table 1 displays the intake of macro-nutrients for different socio-demographic groupings in Denmark.

Table 1. Intake and composition of energy in foods and drinks for different groups of adults

	Energy	Fats (E%)		Carbohydrates (E%)			Proteins
	(KJ/day)	Total	Saturated	Total	Added sugar	Fibres	(E%)
Age							
Under 26 years	10507	35	15	48	12	18	14
26 – 29 years	10228	36	15	45	10	20	14
30 – 39 years	9610	36	15	44	8	20	15
40 – 49 years	9472	37	16	42	7	21	15
50 – 59 years	9392	36	15	43	8	21	15
60 – 69 years	9290	39	17	42	7	23	15
70 years and above	8812	38	17	44	8	22	14
Family type							
Households with children above 7 years	9832	37	15	44	9	21	14
Households with children 0-6 years	9890	37	15	44	9	21	14
Couples	10391	37	16	44	8	20	15
Singles	9116	37	16	44	8	21	14
Social classes							
Social class 1	9918	36	15	43	8	21	15
Social class 2	9614	36	15	44	8	21	15
Social class 3	10090	37	16	44	9	20	14
Social class 4	10599	36	15	45	9	20	14
Social class 5	10281	38	16	44	9	20	14
Geographic							
Capital	9002	36	15	44	9	21	14
Larger town	9410	37	15	44	8	22	14
Rural	9616	38	16	44	9	22	15
Recommended		max. 30			max. 10		

Source: Fagt *et al*. (2004)

The energy share of fats is higher for the older part of the population, in the lower social classes[ii] (class 3-5) and in the rural areas. For example, the oldest age group (70- years), 38 per cent of total energy intake stems from fat, compared with 36 per cent for consumers in the 26-29 years interval. A similar pattern is seen with regard to saturated fats. The intake of carbohydrates is relatively high among the young consumers, especially due to a high intake of added sugar, whereas the intake of fibres is relatively low for the younger age groups. For households with children, the intake of both sugar and fibres is relatively higher than in households without children. The intake of sugar is higher for the lower social classes, whereas the opposite is the case with regard to fibres. The aggregate intake of proteins does not seem to show any particular socio-demographic pattern.

From an overall perspective, the intake of fats exceeds the recommended intake (30 per cent) significantly. The intake of added sugar exceeds the recommended maximum for the younger consumers. It should be noticed that even though the differences between socio-demographic groups shown in table 1 may appear small, they reflect relatively large differences in the composition of foods actually consumed. They probably also reflect considerable differences with regard to the extent of physical activity. The diet of the Danish population has been changing in a more healthy direction during the last decades, partly due to public information campaigns directed towards healthier eating. Among the areas where campaigns have proven successful could be mentioned the consumption of fat, fresh fruit and vegetables. The intake of vegetables and fruits has increased from 279 g a day to 379 g a day on average (Fagt *et al*., 2004). In the same period the fat content in the diet has decreased with 4% points (Fagt *et al*., 2002). Despite these favourable trends the original aims of respectively 600 g of vegetable or fruits per day and a diet with a fat content of 30% have not yet been reached.

Some of these socio-economic differences in nutrient intake may be explained by differences in food habits (see e.g. Nichele 2004, Richelsen *et al*. 2003, Larsen, 2003 or Smed, 2002). Elderly tend to be strongly bounded by traditions and react slower to new trends (Larsen, 2003, Smed, 2002, Groth and Fagt, 2003). However, more alarming is the growing obesity among children and teenagers. This development is mainly caused by unhealthy fast food and too high a sugar intake in combination with too little physical activity (Matthisen *et al*, 2003, Larsen, 2003). Groth and Fagt (2003a) report the diet in the rural areas to be more energy dense than the one consumed in the capital region. In these areas, cooking is more traditional and also more fat-containing than in other parts of the country (Smed, 2002).

Despite the minor differences among socio-demographic groups concerning the intake of macro-nutrients (fat, carbohydrates and protein), there are evident socio-demographic differences in the occurrence of obesity. Reasons for this may include differences in the extent of physical activity or lifestyle in general.

3. Methodology

The analysis of the impacts of food taxes as an instrument to improve the diet in a healthier direction is carried out by means of a model concept, which combines two types of models:

- econometric models of food consumption behaviour in socio-demographic groups
- models for conversion between food consumption and nutrient intake

Whereas the former is based on economic theory, the major content of the latter is basically a matrix of technical conversion coefficients, reflecting the contents of various nutrients (e.g. proteins, fats, carbohydrates, sugar) in different food products. This is equivalent to the consumption technology matrix in Lancaster type models. As in Huang, 1999, we assume that the total quantity of a nutrient may be expressed as the sum of nutrient from various foods:

$\theta_k = \sum_i a_{ki} q_i$, where θ_k is the amount of nutrient *k*, a_{ki} is the amount of nutrient *k* pr unit of food item *i* and q_i is the amount of food item *i*. The model concept is illustrated in figure 1.

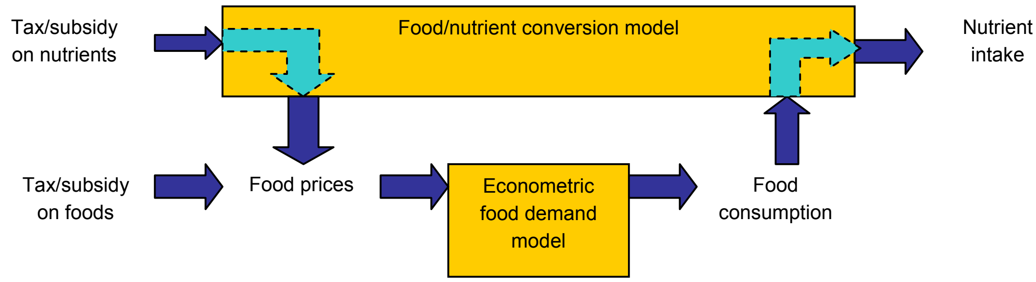

Figure 1. Model concept

The figure illustrates the analysis of two types of tax instruments: taxes/subsidies directly on foods, e.g. vegetables or fruit, and taxes/subsidies on nutrients embedded in different foods, e.g. saturated fats or fibres. In the first case, the tax or subsidy directly affects the prices of the considered commodities. The resulting price change is an input to the econometric food demand model, which in turn determines the response in food demands due to the price change. The changes in demanded quantities can then be converted into changes in the intake of nutrients by means of the food/nutrient conversion model. If instead the tax or subsidy is levied on embedded nutrients, e.g. saturated fats, the first step of the analysis is to convert these taxes into price changes on the food commodities, using the food/nutrient conversion model.

Theoretical approach in food demand model

The analysis takes departure in economic consumption theory, assuming that consumers exhibit utility maximising behaviour subject to a budget constraint. Assuming standard properties of the utility function, this basic assumption implies that the consumption of individual commodities can be derived as a function of the price of the considered commodity, prices of other commodities (substitutes or complements) and the size of the budget available for consumption. Psychological aspects like e.g. attitudes or habits may (explicitly or implicitly) be embedded in the utility function.

For empirical implementation, a functional form is needed. In the study below, the Almost Ideal Demand (AID) model, introduced by Deaton and Muellbauer (1980), is used. Dynamics in consumer behaviour (e.g. habit formation or storage effects) are investigated by introducing lagged budget shares to the AID model, as suggested by Alessie and Kapteyn (1991), Assarson (1991) and Kesavan *et al.* (1993). According to this augmented AID specification, commodity *i*'s share w_i of the total commodity group budget can be specified as:

$$(1) \qquad w_{it} = \alpha_i + \sum_j \gamma_{ij} \ln p_{jt} + \beta_i (\ln y_t - \ln P_t) + \sum_j \theta_{ij} w_{j,t-1} + \varepsilon_{it}$$

Assuming that food consumption is weakly separable from the consumption of other goods and services p_{jt} can be considered as the price of commodity (food type) *j* at time *t*, and y_t as the total food consumption budget, $\ln P_t = \alpha_0 + \sum_k (\alpha_k + \theta_k w_{kt-1}) \ln p_{kt} + ½ \sum_k \sum_j \gamma_{kj} \ln p_{kt} \ln p_{kt}$ is an aggregate food price index. $\alpha_i, \beta_i, \theta_{ij}, \gamma_i$, are parameters to be estimated. The aggregate food price index can reasonably well be approximated by the Törnquist index: $\ln P_t - \ln P_0 = \sum_i ½ (w_{i0} + w_{it}) \cdot (\ln p_{it} - \ln p_{i0})$ (Moschini, 1995). For theoretical consistency, the system of budget share equations is required to satisfy the properties of adding-up, linear homogeneity, Slutsky symmetry and concavity.

This dynamic specification of the AID model allows habit formation and storage effects to be accounted for in the analysis. This is an important feature of the model, as it is estimated on weekly data, cf. below. Furthermore, a linear trend variable is added to the model in order to capture possible food consumption trends, which cannot be explained by economic variables like prices and total food budget size nor the dynamics of the model. Examples of such trend elements could be changes in attitudes, changes in the time available for preparing meals, etc. As weekly consumption data may also be subject to seasonality, dummy variables representing such seasonality are included in the empirical model specification.

Food consumption data

The data material for the present analysis consists of weekly household panel data from a representative panel of Danish food consumers (approximately 2000 households) from GfK ConsumerScan, spanning the period from January 1997 to January 2000. Weekly shopping records are collected, reporting the households' purchases in terms of quantity, price, expenditure, brand, special product characteristics (e.g. organic, special packaging), place of purchase, etc. at a very detailed level. For empirical tractability, the detailed commodities in the weekly shopping reports are aggregated into 23 broader food categories[iii]. Unfortunately the data only comprise food purchased for consumption at home and does not include consumption of alcoholic and non-alcoholic beverages and expenditures on food away from home. Data is less comprehensive on snack purchases in kiosk and other nearby stores for other family members than the dairy keepers as it is only included if these are told to the dairy keeper. For each household in the panel, a wide range of background information has been recorded, including e.g. family type, age, social class, geographical localization, etc. Especially age, family type, geographical localisation and social class (reflecting level job position) have been found to have major influence on dietary choices in previous studies (e.g. Smed, 2002, Fagt *et al*., 2004).

Econometric estimation of food consumption model

In principle, the data material might enable use of micro-econometric methods for analyzing the demand for foods, if the panel structure of the data were to be exploited fully. However, in this respect, the data material has one shortcoming: it only contains price information of the commodities purchased, whereas information concerning the prices of commodities not chosen by the individual household is either non-existing or imperfect. For this reason, the data have been aggregated to pure time series data for different groupings of households, 7 age groups, 3 geographical regions and 5 social classes. These three socio/demographic characteristics, together with family type are found to have major influence on dietary choices (Smed, 2002, Fagt *et al*., 2004, Angulo *et al*, 2002).

The demand systems are estimated separately for each of the groups using maximum likelihood estimation[iv]. Adding up is imposed on the system, while the properties of linear homogeneity and symmetry were checked during estimation. For all demand systems homogeneity is accepted while symmetry is accepted for most systems. Test for multicollinarity (condition index) and for misspecification (White and Breusch–Pagan tests for heteroscedasticity and Godfrey's test for autocorrelation) are applied. There are indications of multicollinarity between total food consumption and the intercept. This problem is handled by demeaning the variables and omitting the intercept. There are no signs of systematic heteroscedasticity or autocorrelation.

Within the estimation process, two separability structures have been tested. First, a structure (structure 1) where the 23 food groups are grouped within three major food groups (meat and fish, dairy, other foods) are tested against at system of no structure. Second a structure (structure 2) where the 23 food groups are grouped within six major food groups (dairy, meat and fish, processed meat, fruit and vegetables, fats and other foods) are tested against a system of no structure. For many socio-economic groups the hypotheses of that structure 2 is just as good as no structure cannot be rejected while the hypotheses that structure 1 is just as good as no structure are rejected. The system is estimated using structure 2. The separability is tested according to tests in Moschini *et al.* (1994) and Moro and Moschini (1996).

Based on the estimated coefficients and average budget shares, full matrices of own- and cross price elasticities are calculated for each of the socio-demographic groups, according to the formulas (where δ_{ij} is the Kronecker delta) (Edgerton *et al*. 1996).

(2) $$E_i = 1 + \frac{\beta_i}{w_i}$$ income elasticity:

(3) $$\varepsilon_{ij} = \frac{\gamma_{ij} - \beta_i \cdot \left[\beta_j \cdot \ln(y/P) - w_j - ½ \cdot (\gamma_{ij} + \gamma_{ji}) \cdot \ln(p_i)\right]}{w_j} - \delta_{ij}$$ price elasticity:

These elasticities are used to compute the changes in the composition of the food consumption as a response to changes in the relative prices. Selected estimated own-price food demand elasticities for the socio-demographic groups are shown in table 2. Although there are variations across age groups, the own-price elasticities do not tend to show any systematic pattern in this respect, except that the elasticities of the youngest and the oldest consumers in some cases deviate from the patterns of the other age groups. One explanation for this deviation could be that a relatively large number of the households in these extreme age groups consist of single persons and this may also affect the household's food consumption behaviour. Among social classes, the price responsiveness appears to be higher for households in the lower social classes, presumably because the budget constraint is more binding for these households than for households in the upper classes. In general, the price responsiveness is larger in rural areas than in the towns (and the Capital region in particular) for most commodities, except fruits and vegetables. These geographic differences may reflect differences in the composition of social classes in urban and rural areas, but may also reflect cultural differences.

Table 2. Selected own-price food demand elasticities for socio-demographic groupings

	Butter	Margarine	Beef	Pork	Poultry	Sugar	Fruit	Vegetables
Age								
	-1.10	-1.25	-1.92	-2.02	-1.26	-1.01	-1.60	-1.41
< 26 years	*(0,002)*	*(0,000)*	*(0,058)*	*(0,056)*	*(0,056)*	*(0,003)*	*(0,049)*	*(0,000)*
	-1.04	-1.01	-1.01	-1.52	-1.97	-0.55	-0.93	-0.94
26 – 29 years	*(0,001)*	*(0,008)*	*(0,002)*	*(0,016)*	*(0,115)*	*(0,012)*	*(0,000)*	*(0,000)*
	-3.92	-2.78	-1.61	-1.57	-1.28	-1.00	-1.36	-1.35
30 – 39 years	*(0,091)*	*(0,044)*	*(0,011)*	*(0,058)*	*(0,118)*	*(0,000)*	*(0,000)*	*(0,058)*
	-1.15	-1.09	-1.46	-1.02	-1.35	-1.02	-1.40	-1.18
40 – 49 years	*(0,056)*	*(0,000)*	*(0,094)*	*(0,031)*	*(0,033)*	*(0,002)*	*(0,000)*	*(0,060)*
	-1.15	-1.12	-1.32	-1.87	-1.70	-0.77	-1.69	-1.40
50 – 59 years	*(0,056)*	*(0,000)*	*(0,098)*	*(0,060)*	*(0,021)*	*(0,009)*	*(0,055)*	*(0,081)*
	-0.17	-0.75	-1.60	-1.29	-1.93	-1.33	-0.82	-1.12
60+ years	*(0,083)*	*(0,000)*	*(0,099)*	*(0,000)*	*(0,077)*	*(0,073)*	*(0,046)*	*(0,067)*
Social class								
	-0.66	-0.69	-0.64	-0.62	-0.79	-0.97	-0.68	-1.14
Social class 1+2	*(0,001)*	*(0,011)*	*(0,446)*	*(0,411)*	*(0,446)*	*(0,049)*	*(0,054)*	*(0,081)*
	-1.20	-1.76	-0.89	-1.05	-0.86	-1.01	-1.20	-1.18
Social class 3	*(0,000)*	*(0,000)*	*(0,102)*	*(0,084)*	*(0,078)*	*(0,003)*	*(0,053)*	*(0,070)*
	-1.38	-2.07	-1.87	-1.43	-1.42	-1.02	-1.27	-1.30
Social class 4	*(0,000)*	*(0,005)*	*(0,070)*	*(0,039)*	*(0,016)*	*(0,003)*	*(0,005)*	*(0,046)*
	-1.55	-1.98	-1.80	-2.00	-1.87	-1.03	-1.22	-1.47
Social class 5	*(0,001)*	*(0,006)*	*(0,014)*	*(0,045)*	*(0,014)*	*(0,003)*	*(0,059)*	*(0,082)*
Geography								
	-1.03	-1.01	-0.67	-0.73	-0.83	-0.70	-1.68	-1.29
Capital	*(0,000)*	*(0,000)*	*(0,020)*	*(0,062)*	*(0,020)*	*(0,008)*	*(0,031)*	*(0,011)*
	-1.46	-1.85	-1.44	-0.56	-1.33	-1.04	-0.70	-0.71
Town	*(0,001)*	*(0,002)*	*(0,078)*	*(0,035)*	*(0,036)*	*(0,004)*	*(0,032)*	*(0,012)*
	-1.51	-1.79	-1.75	-1.51	-1.76	-1.25	-0.49	-0.64
Rural	*(0,002)*	*(0,000)*	*(0,118)*	*(0,011)*	*(0,016)*	*(0,027)*	*(0,022)*	*(0,013)*

Standard deviations for the calculated elasticities are approximated by using first order Taylor series expansion. These own-price elasticities represent the dominating demand effect in the demand response to price changes, induced by e.g. changed food taxes. In addition, the econometric model also includes cross price effects. For some of the socio-demographic groups, some of the price elasticity estimates are subject to some uncertainty, either because the data material used for the estimation is relatively small or because the households within this data material exhibit relatively heterogeneous responses to price variations.

Conversion between food consumption and nutrient intake

Due to the data used for econometric estimation, the estimated parameters represent changes in food consumption measured in fixed-price value terms. In order to assess the nutritional impacts of changed price relations, there is a need for converting these value estimates into physical quantities, and subsequently into quantities of individual nutrients. Based on aggregate fixed-price value data and aggregate physical quantity data for the consumption of foods, a matrix for converting value data to physical quantities has been constructed.

From data on physical quantities of individual food components, the intake of various nutrients can be estimated using nutrient coefficients from the Danish Food Database, which describes the average content of a number of micro- and macro-nutrients in a large range of the most usual food commodities on the Danish market. For the present purpose, these coefficients have been aggregated to the level of detail obtainable in the econometric food demand model. The nutrient coefficients applied in the present study are displayed in table 3.

Table 3. Selected aggregate nutrient coefficients

	Fats, total	Saturated fats	Sugar	Fibres
	g/100 g	g/100 g	g/100 g	g/100 g
Milk	2.0	1.2	0.9	0.1
Fats	81.2	45.8	0	0.0
Eggs	11.2	3.0	0	0.0
Cheese	23.9	14.8	0	0.0
Pork	14.4	5.5	0	0.0
Fish	4.2	0.9	0	0.0
Flour, bread etc.	2.5	1.3	0	5.1
Sugar	0.0	0.0	99.9	0.0
Fruit/vegetables/potatoes	0.6	0.2	0	1.7

Source: Danish Food Database (2005)

4. Scenario analysis

As mentioned above, there appears to be a problem with too high intake of fats (where saturated fats are the most critical from an obesity point of view) and added sugar, and too little intake of fibres, according to recommendations from WHO (2003), Willets (2003) and The Nordic Council of Ministers (1996). In order to illustrate the use of food taxes or subsidies as instruments to regulate food consumption and the intake of nutrients into more healthy directions, we consider 4 different regulation scenarios (table 3). A common feature of all these regulation scenarios is that they intervene in the formation of consumer prices on the foods. The tax scenarios a)-c) aim at increasing the consumer prices for foods with unhealthy components (fats or sugar) in order to reduce the demand for such foods, whereas the subsidy scenario d) aims at lowering the price of a healthy food component (fibres) in order to stimulate the demand for foods rich in fibres.

Table 3. Scenario definitions

Scenario	Content
a)	Tax on all fats, 7,75 DKK/kg
b)	Tax on saturated fats 7,90 DKK/kg.
c)	Tax on added sugar 6,23 DKK/kg
d)	Subsidies on fibres 10,70 DKK/kg.

All scenarios can be considered as taxes/subsidies on nutrients (cf. figure 1). Hence, the tax rates on the considered nutrients are converted to price changes on food commodities by means of the food/nutrient conversion model. Subsequently, the resulting food price changes are used as inputs to the econometrically estimated food consumption behaviour model, which in turn determines the changes in demanded food quantities. Finally, these changes are converted to changes in nutrient intake by means of the food/nutrient conversion model.

All the scenarios are scaled equally in the sense that the aggregate economic welfare loss is identical across scenarios, in order for comparisons across scenarios to make sense. The welfare loss corresponds to 0.2 per cent of the aggregate food budget. The welfare loss is defined as the net loss of consumers' surplus - calculated as an approximation to the equivalent variation[v] - plus the net loss of tax revenue.

5. Results

Results of the scenarios on the total intake of energy are shown in table 5. In the initial situation (cf. table 1), the largest energy intake occurs with the young consumers, consumers in the lower social classes, and people in the rural areas. A tax on fats in general appears to be a relatively effective instrument to reduce the intake of energy, for example a 7 per cent reduction for consumers in the age groups below 29 years. With a few exceptions, the total energy impact of a fat tax is relatively homogenous across age groups and shows a slightly stronger response in the lower social classes than in the upper classes. The effects on energy intake appear to be stronger in the cities than in the rural areas.

Table 5. Scenario effects on total energy intake per day

	Initital level	Fat tax scenario	Sat. fat tax scenario	Sugar tax scenario	Fibre subsidy scenario
	kJ/day	---------------------------	per cent change	-------------------------	
Age					
Under 26 years	10507	-7%	-4%	-2%	2%
26 – 29 years	10228	-7%	-5%	-2%	2%
30 – 39 years	9610	-17%	-12%	-1%	1%
40 – 49 years	9472	-7%	-4%	-2%	1%
50 – 59 years	9392	-5%	-4%	-2%	2%
60 – 69 years	9290	-7%	-4%	-2%	1%
70 years and above	8812	11%	8%	-1%	1%
Social classes					
Social class 1+2	9718	2%	3%	0%	5%
Social class 3	10090	-7%	-4%	-2%	1%
Social class 4	10599	-8%	-5%	-2%	1%
Social class 5	10281	-9%	-6%	2%	1%
Geography					
Capital	9523	-9%	-6%	-2%	1%
Larger town	9884	-7%	-8%	-5%	-2%
Rural	10016	-1%	-4%	-4%	-4%

The impacts of a tax on saturated fats only are quite similar to those for a tax on all fats, although at a smaller scale. One interesting difference is however the geographic pattern of the reduction, which deviates from the effects of a general fat tax in that in rural areas the reduction in energy intake is larger than for a general fat tax, because the demand for some of the foods most rich in saturated fats is relatively price sensitive in the rural areas (e.g. butter and pork). It should be noted that the calculated increase in energy intake for older consumers and social class 1 is due to a considerable uncertainty on the estimated price elasticities for butter and other fats, as well as on the cross price elasticities between different fat-containing foods, in these consumer groups. A tax on sugar in general reduces the energy intake by around 2 per cent in most socio-demographic groups, although there seems to be a somewhat stronger reduction in the upper social class, and a stronger reduction outside the capital. The increased energy intake in social classes 2 and 5 is due to a relatively strong substitution from sugar-containing foods towards other foods. A subsidy to fibres in the food stimulates the energy intake by around 1 per cent in most groups, however with a stronger effect in the upper social classes, and a negative effect outside the capital region.

If a policy objective of the taxes were to induce the strongest energy intake reduction in groups with the highest initial levels, the considered instruments are only successful to a limited extent. Concerning a fat tax, the good news is that it tends to equalize the energy intake across social groups, while deepening the regional differences and being fairly neutral among age groups. On the other hand, a sugar tax or a fibre subsidy tends to reduce the regional differences while being fairly neutral with regard to age and social differences.

Table 6. Scenario effects on the intake of saturated fats

	Base level	Fat tax scenario	Sat. fat tax scenario	Sugar tax scenario	Fibre subsidy scenario
	E%	---------------------	percentage point E% change	------------------	
Age					
Under 26 years	15,0%	-1,4%	-0,9%	0,4%	-0,3%
26 – 29 years	14,6%	-1,1%	-0,7%	0,3%	-0,2%
30 – 39 years	15,0%	-3,8%	-2,7%	0,2%	-0,2%
40 – 49 years	16,0%	-1,1%	-0,8%	0,2%	-0,1%
50 – 59 years	15,4%	-0,1%	-0,2%	0,2%	0,1%
60 – 69 years	17,0%	-0,6%	-0,4%	0,3%	-0,3%
70 years and above	16,7%	3,6%	2,3%	0,5%	-0,2%
Social classes					
Social class 1+1	15,0%	0,9%	0,3%	-0,3%	-0,3%
Social class 3	16,1%	-1,1%	-0,8%	0,3%	-0,2%
Social class 4	15,4%	-1,3%	-1,3%	0,1%	-0,4%
Social class 5	16,1%	-1,1%	-0,9%	1,3%	-0,5%
Geographic					
Capital	15,2%	-0,3%	-0,2%	0,2%	-0,2%
Larger town	15,5%	0,3%	0,8%	0,8%	0,4%
Rural	15,9%	-0,7%	0,2%	2,4%	0,3%

Table 6 shows the effects of the regulation scenarios on saturated fats's share of total energy intake, which is one of the key determinants for overweight and obesity problems. For consumers in the younger age group, a general fat tax reduces saturated fats' energy share by 1.4 percentage point, from 15.0 to 13.6 per cent of total energy intake. The effects of an 'all fats' tax or a 'saturated fats' tax seem to be decreasing with age, i.e. these taxes schemes seem to deepen the differences between age groups, but there are no clear patterns with regard to social classes or geographic location. Although the effects are moderate, a tax on sugar tends to increase saturated fats' share of total energy intake, due to a reduction in the intake of carbohydrates – especially sugar – and some substitution towards other foods. This increase is stronger for the youngest and oldest consumers, for the lower social classes and for the rural citizens – thus tending to increase the inequalities with regard to intake of saturated fats. If instead a consumption subsidy on fibers is considered, the reverse pattern is observed.

Table 7. Scenario effects on the intake of sugar

	Base level	Fat tax scenario	Sat. fat tax scenario	Sugar tax scenario	Fibre subsidy scenario
	E%	--------------------	percentage point E% change	----------------------	
Age					
Under 26 years	12,2%	1,8%	1,1%	-1,4%	-0,1%
26 – 29 years	9,5%	1,1%	0,6%	-0,6%	0,0%
30 – 39 years	8,2%	1,7%	1,1%	-1,1%	-0,1%
40 – 49 years	7,5%	0,6%	0,5%	-0,9%	-0,1%
50 – 59 years	7,6%	-0,9%	-0,6%	-0,8%	-0,1%
60 – 69 years	7,3%	0,9%	0,6%	-1,3%	0,1%
70 years and above	8,4%	-0,1%	-0,1%	-1,6%	0,1%
Social classes					
Social class 1+2	7,8%	0,1%	-0,1%	-1,0%	-0,1%
Social class 3	8,9%	1,0%	0,7%	-1,1%	0,0%
Social class 4	9,5%	1,3%	1,0%	-1,2%	0,1%
Social class 5	8,9%	1,4%	0,8%	-1,5%	0,2%
Geographic					
Capital	9,1%	-1,0%	-0,7%	-0,8%	-0,1%
Larger town	8,4%	-1,8%	-1,0%	-0,9%	0,2%
Rural	8,6%	0,6%	0,8%	-1,4%	0,6%

Added sugar is considered to be another crucial factor behind the growing overweight and obesity problems, especially for some groups of the population. Table 7 shows the effects of the regulation scenarios on added sugar's share of total energy intake. The considered sugar tax scenario tends to reduce sugar's share of total energy intake by 1.4 percentage point, e.g. from 12.2 to 10.8 per cent for consumers below 26 years. The sugar tax seems to have the strongest effect for the younger and the older consumers, whereas the response of middle-age consumers tends to be slightly more moderate. The response to a sugar tax is also stronger in the lower social classes and in the rural areas. Compared with the initial intake, the sugar tax tends to reduce the inequalities in sugar intake, yielding the largest decreases for the consumer groups most in need for reductions.

Taxes on all fats or saturated fats tend to increase sugar's share of total energy intake for many consumer groups – most significantly for the younger consumers, consumers in the lower social classes and consumers in rural areas, thus aggravating the problems with too high intake of sugar in these groups. A subsidy on fibres has only small effects on the intake of sugar in most socio-demographic groups.Tables 6 and 7 consider the effects on the intake of saturated fats and sugar. Naturally, the scenarios also have impacts on the intake of proteins, other fats and carbohydrates, fibres etc. In general, these do not show systematic patterns across consumer segments and are therefore not presented here. The results are, as mentioned above, based on purchase data which do not include food away from home and beverages. Furthermore the data do only partly cover ad hoc purchases in kiosks from other family members than the dairy keeper. This means that there might be a certain bias in the results. We assume this bias to be of minor importance since often the costs of ingredients in goods purchased in kiosks and restaurants constitute a minor share of the price[vi]. Hence, a tax on sugar, for instance, will only constitute a minor change in the price of e.g. soft drinks and thus probably would not induce major changes in the consumption of these soft drinks. Consequently, the major changes can be expected to occur in the consumption covered by the data in this analysis..

6. Discussion

This paper has analysed the use of food taxes and subsidies as instruments in health policy and their nutritional effects for different socio-demographic groups. From an overall perspective, a tax on fats reduces the total energy intake as well as fats' share (total fats as well as saturated fats) of total energy, but increases sugar's energy share for most consumers. This is the case both for a tax on all fats and a tax on saturated fats only. On the other hand, a tax on sugar reduces the share of sugar but increases the shares of different fats, whereas the effects on fats' and sugar's energy shares of a subsidy on fibres are small or negligible.

The analysis enables evaluation of the effects for different socio-demographic groups, and thus the usefulness of the considered instruments for remedying current socio-demographic inequalities with regard to the extent of obesity problems. Whereas the concern for obesity and unhealthy diets is most pronounced for citizens in the lower social classes, in the rural areas and among the younger, the evaluations show that none of the considered instruments have particularly advantageous effects for these groups. Although fat taxes may reduce the total energy intake most for those citizens most in need, they also tend to increase the share of sugar for these groups. On the other hand, a tax on sugar reduces the intake of sugar for those in need of reducing their sugar intake, but at the same time stimulates the share of saturated fats. The considered fibre subsidy tends to yield the most desirable distributional effects, but in order to obtain a significant effect of such subsidy, a relatively high rate of support is needed – thus making the cost of the intervention relatively high.

Based on these findings, it may be concluded that general tax or subsidy instruments cannot solve the problems with regard to nutrition and obesity for all groups of consumers. However, this does not exclude the possibility of using such instruments in combination with other regulations. Economic instruments may interact with such other types of regulation, e.g. information campaigns or rule-based regulation. Thus, it may be considered whether information can contribute to enhance the effectiveness of economic instruments – and vice versa, so that price changes can induce consumers' increased attention about the nutritional aspects of the foods consumed. Taking into account the relatively low precision of taxes/subsidies towards specific consumer segments, a combined regulation utilising both tax/subsidy instruments and other types of regulation might be a proper way to go. This issue might be an avenue for further research.

The issue of administrative costs has only to a limited extent been touched upon in the present study. It is evident that the administrative cost will differ between the considered regulation instruments. Taxes or subsidies on underlying nutrients like saturated fats or fibres will be demanding with respect to documentation and control than e.g. a tax on sugar. Administrative costs are thus expected to be higher in scenario b) or d) than in scenario a) or c). There will also be differences a to where in the food supply chain the instruments can be implemented. New taxes or subsidies may further give rise to border trade issues and circumvention in terms of increased farm-gate sales etc.

A number of barriers may hamper the effectiveness of economic regulation instruments. One such barrier is consumers' insufficient awareness of prices and nutritional characteristics of the foods – an aspect that may be corrected if economic regulation is accompanied by increased information. Another barrier may be rigidities in consumers' adaptation to new price conditions due to habits, scarcity of time etc. Such rigidities will however also imply a barrier for the effectiveness of most other types of regulation, but their importance may differ across socio-demographic groups, e.g. family types or socio-economic classes. The above quantitative analyses abstract from supply-side adjustments. A tax on a food commodity and the resulting lower demand may lead to reduced supply and thus lower price, which to some extent offsets the effects of the tax and this effect has not been accounted for in the calculations. Also adjustments due to changed government revenues have been ignored. If a food tax yields a net revenue, this will in principle enable lowering other taxes and hence some of the distortionary effects on e.g. labour supply caused by these taxes. However, in the present scenarios such effects may be considered negligible. There is however also a risk that e.g. tax reductions are not fully transmitted to consumer prices, but instead lead to increase profits in various stages of the supply chain, to the extent that competition is not sufficient. On the other hand, higher taxes will more likely be fully transmitted to consumer prices: Such asymmetries may have implications for the choice of instrument.

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Notes

[i] Obesity is in this paper defined as a BMI > 30. BMI is calculated as weight $\frac{Weight\ i\ kg}{(Height\ i\ m)^2}$

[ii] Social classes:

1. Self-employed with more than 20 employees or academic grade, salaried employees with more than 50 subordinates or academic grade, proprietors.
2. Non-academic self-employed with 6-20 employees, salaried employees with 11-50 subordinates, farmers with more than 3 subordinates
3. Self-employed with 0-5 employees, non-academic salaried employees with 1-10 subordinates, farmers with 0-3 subordinates
4. Salaried non-academic employees with no subordinates, skilled manual workers
5. Unskilled manual workers, students, pensioners and others without employment

[iii] Eggs, other foods, other meat, other dairy, fish, processed fish, grain based products, poultry, processed fruit and vegetables, fresh fruit, fresh vegetables, potatoes, biscuits and cakes, milk, margarine, beef, cheese, processed meat, rice and pasta, butter, sugar and sugar products, pork, curdled milk products

[iv] The separation of the panel in separate groups in stead of introducing socioeconomic variables by e.g. translation, scaling or Lewbel's modifying functions approach are similar to e.g. Park *et al.* (1996) and Huang and Lin (2000).

v The equivalent variation is calculated as an approximation to the expression given by Diewert (1989), i.e. the relative change in aggregate quantity, multiplied by the initial budget for food consumption

[vi] This is for example the case for many kinds of soft drinks were the price mainly is paid for the brand name.