The Public Health Impacts of a Fat Tax

Richard Tiffin, Matthieu Arnoult

Full Title: The Public Health Impacts of a Fat Tax

October 1, 2010

Running title: Impacts of a Fat Tax

R. Tiffin PhD (University of Reading) and M. Arnoult PhD (Scottish Agricultural College)

Address for Correspondence:

Richard Tiffin
Department of Agricultural and Food Economics
Agriculture Building
Earley Gate
University of Reading
PO Box 237
Reading
RG6 6AR
phone: 0118 378 8965
fax: 0118 975 6467
e-mail: j.r.tiffin@reading.ac.uk

Acknowledgment

The work reported in the paper was funded by ESRC under the Rural Economy and Land Use programme.

Background/Objective: Previous studies have analysed impacts on average intakes. Agueably however intakes that are of real concern are those which are some distance from the recommendations. Fiscal measures may have a limited impact on such diets and, as a result, on health. We measure the impact of a fiscal intervention on the the risks of diet related disease accounting for the full range of diets.

Subjects/Methods: Demand equations are estimated with data from 6760 households in the UK Expenditure and Food Survey. The model is used to simulate the impacts of a policy in which a tax based on saturated fat content is combined with a subsidy on fruit and vegetables. Changes in consumption are used to compute the effects on the risks of a range of diet related disease using measures of relative risk. In contrast with other studies we simulate the impacts of the fiscal regime at the level of the individual households in the sample.

Results: The subsidy brings mean levels of fruit and vegetable consumption in line with dietary recommendations but the tax is insufficient to achieve this goal for fat intakes. Once the changes in diet are converted into changes in the risks of disease the impacts of the policy are negligible. A substantial part of the population continues to consume an unhealthy diet.

Conclusion: Fiscally based interventions should be considered amongst a suite of policy interventions which also include policies aimed at improving the poorest of diets.

Keywords: nutrition policy; models, economic; fat tax.

Introduction

Public interest in the use of fiscal measures to regulate unhealthy diets has recently been reawakened by the proposal debated and rejected at the conference of the Scottish Local Medical Committee that a tax on chocolate might contribute to a reduction in obesity. A similar motion was debated in 2003 at the BMA annual representative meeting where a motion to impose a tax on saturated fat was defeated (Beecham; 2003). Interest extends to the US where a recent paper (Brownell and Frieden; 2009) has advocated the introduction of a tax on sugared drinks, an option which is amongst proposals that are currently under consideration by the United States Senate Committee on Finance as a means of raising revenue for health care reform. Evidence regarding the impacts of a fiscal policy on diet tends to focus on changes in the aggregate levels of food consumption of unhealthy products in the population as a whole. For example Marshall (2000) and Mytton et al. (2007) extend VAT in the UK to products regarded as the main sources of saturated fats. Mytton et al. (2007) estimates that the ensuing variations in ischemic heart disease would lead to the avoidance of between 900 and 1,000 premature deaths every year. Whilst many

studies (eg Chouinard et al.; 2005; Kuchler et al.; 2005) find that the impacts of a fiscal intervention on consumption are likely to be modest, these authors stress that a fat tax would be a useful tool to generate a revenue that could be allocated to prevention or information campaigns. In this vein and using Danish data, Jensen and Smed (2007) investigate the effects of nutrient- and food-based taxes, coupled with subsidies in order to produce revenue-neutral scenarios. In line with other studies, they find that dietary effects would be minimal, but, as far as nutrient intake is concerned, better results are obtained by focusing the tax on nutrient content rather than on specific food items (*e.g.*, saturated fats *vs.* red meat).

A number of messages are emerging in this rapidly evolving literature. The results suggest that the impacts of a tax on diet may not be as large as might be hoped but by targeting taxes at specific nutrients more promising results may be obtained. Additionally, by coupling the negative impacts of taxes on unhealthy food with measures designed to promote healthy consumption, the effectiveness of the policy might be further enhanced. We therefore analyse the impacts of a tax based specifically on the saturated fat content of foods coupled with a subsidy on fruit and vegetables. We also argue that it is important to to consider the distribution of nutrient consumption in the population and to measure not only the impacts on average intake but also on health across the population. In doing so we show that an undifferentiated fiscal policy for all individuals has a limited impact on the overall health of the population.

Method

We report the results of a study which measures the impacts of a tax on saturated fats, coupled to a subsidy on fruit and vegetables, designed so as to create a revenue-neutral scheme. We explore the impacts of such a policy in achieving Department of Health guidelines and on the risk of being affected by diet related diseases. We estimate a system of demand equations as the basis for the model which we use to simulate the effects of the price changes. Our model employs the widely used Almost Ideal Demand System (Deaton and Muellbauer; 1980) which is represented as follows:

$$s_{it} = \alpha_i + \sum_{j=1}^{m+1} \gamma_{ij} \ln p_{jt} + \beta_i \ln \left(\frac{e_t}{P_t} \right) + \psi_i' h_t + u_{it} \quad (1)$$

$$i = 1, \ldots, m+1 \text{ and } t = 1, ...T \quad (2)$$

$$(u_{1t}, \ldots u_{mt})' \sim N(\mathbf{0}, \mathbf{\Sigma}) \quad (3)$$

where s_{it} is the share of total expenditure (e_t) accounted for by expenditure on the i^{th} good in the t^{th} household, p_{jt} is the price of the j^{th} good to the t^{th} household, $P_t = \prod_j p_{jt}^{s_{jt}}$ is Stone's price index and h_t is a vector of variables that describes the t^{th} household's socio-demographic characteristics[1]. The use

[1]We used an extensive list of demographic variable to describe: household composition; social class; region; age; sex and ethnicity.

of a system of demand equations ensures that the changes in demand for the different food groups are consistent with one another fully taking into account cross price effects as suggested by Kennedy and Offutt (2000), and Mytton et al. (2007). These cross price effects are important because, for example, a reduction in saturated fat consumption resulting from lower levels of butter demand could be partially offset as consumers substitute butter with lower fat spreads. Furthermore our model fully recognises that the consumer makes choices within a fixed budget constraint. Thus the decision regarding how much less to spend on a taxed product will be partially influenced by the savings that can be made elsewhere in the consumer's budget. We estimate the demand models using household data from the 2005-6 UK Expenditure and Food Survey (EFS). The data are collected through the completion a two-week diary for each individual over seven years of age which is supplemented with the use of till receipts. Each participating household does so voluntarily. An important consideration when estimating demand models is the treatment of censored observations where the level of consumption of a particular good in a household is zero during the survey period. In order to address this we employ a version of the Infrequency of Purchase Model (IPM) introduced by Blundell and Meghir (1987).[2]

[Table 1 about here.]

It is not possible to estimate a single model comprising all the food items required in our analysis. Instead, models comprising only a few food groups at a time must be estimated and these food groups are detailed in table 1. We use a hierarchical approach in which a top level model is used to explain the allocation of expenditure between the broad categories in the first column of table 1. Six further models are estimated to explain the partition of expenditure amongst the narrower categories set out in the third column. The price elasticities obtained from each of these models assume that expenditure on the group of foods within the model remains constant as the price change takes place. For example the own price elasticity for fresh fruit and vegetables that is obtained from the fruit and vegetables system assumes that the total expenditure on the five types of fruit and vegetables in the model remains constant. This assumption it likely to be unrealistic: a reduction in the price of fresh fruit and vegetables is likely to induce consumers to spend more on all fruit and vegetables. To address this problem, estimates from the two levels of the hierarchy are combined using the approach suggested by Edgerton (1997) to give overall elasticities which do not assume that expenditure within the 5 groupings remains constant.

The choice of the categories outlined in table 1 is a balance between nutritional rationale and specifying a model which can be estimated econometrically. From a nutritional perspective the ideal would be to estimate at a level that is sufficiently disaggregated to allow for all of the substitution possibilities that are likely to result from a tax that is imposed differentially according to the

[2]Full details of our adaptation of the AIDS are available in a working paper (Tiffin and Arnoult; 2008).

saturated fat content of the food. Thus we include skimmed, semi skimmed and whole milk, and crisps, chips and fresh potatoes separately in the model. In some cases however the aggregations are less than ideal from a nutritional perspective. For example we had to combine butter and margarine in a single aggregate because the levels of censoring across these two categories made it impossible to obtain meaningful estimates for a more disaggregated model. It should be noted however that the tax rate that is computed for a group such as this reflects the observed composition of the aggregate within the sample and therefore, whilst substitution between butter and margarine might not be captured meaningfully, substitution away from the category as a whole will be picked up in the simulations.

We use our model to simulate the impact of a fat tax on intakes and on health. We use Department of Health dietary reference values as a bench mark to assess the impacts of the policy. Dietary reference values recognise that nutrient requirements differ between individuals and are designed to ensure that almost the entire population's nutritional needs are met. Implicit in these guidelines therefore is a recognition that a distribution of nutrition intakes across the population in which a substantial number of people consume below the guidelines does not necessarily mean that a large number of people face a significant health risk. There is however evidence to suggest that some socio-economic groups have diets which are particularly poor (Food Standards Agency; 2007) and it is unlikely that this variation is all attributable to differences in nutrient requirements. We therefore base our analysis on the diets of the individual households within the sample so that we can assess the impacts of the policy on the whole distribution of nutrient intakes. Using our model of consumer demand, we estimate changes in consumption for every household in the sample after implementation of a tax policy.

To summarise the impact of the tax on the distribution of nutrient intakes on each of the individual households in the sample we convert the pattern of nutrient intakes to a single metric which gives an indication of the unhealthiness of particular distribution nutrient intakes. We measure dietary health using the odds O_i of being affected by a particular diet related condition and, in common with much of the literature, assume that these are related to the level of exposure x_i with a logistic function:

$$ln\left(O_i\right) = ln\left(\frac{p_i}{1-p_i}\right) = \alpha + \beta x_i \tag{4}$$

In order to measure the risk of being affected by a diet related condition across a range of intake levels we use estimates of β from the literature to compute the relative risk RR compared to the intake recommended in DoH guidelines (DoH; 1991):

$$RR_i = \frac{O_i}{O_0} = e^{\beta(x_i - x_0)} \tag{5}$$

where x_0 is the recommended intake level. The population risk associated with a given distribution of nutrient intakes is then computed as the weighted average:

$$PR = \sum w_i RR_i \tag{6}$$

where w_i is the proportion of the population consuming x_i. Our estimates of population risk therefore measure the average odds of the population being affected by a condition relative to the case where the whole population conforms to dietary guidelines for the food or nutrient in question. We compare the population risk before and after the policy to measure its effectiveness. The construction of this measure implies that diets which are far away from the reference value are given proportionately greater weight than those that are close to the value. Whilst we recognise that it is not universally true that an individual who consumes below the reference value inherently has a greater risk of disease than another individual who is close to the reference value, we argue that our measure is representative of general societal concern for those individuals who consume particularly poor diets.

A variety of alternative taxation regimes have been examined in the literature. Nnoaham et al. (2009) consider a range of scenarios in which VAT at 17.5% is charged either on a subset of foods (milk, butter, cheese, biscuits, cakes and pastries) which are deemed to be high in saturated fats or those which are deemed to be unhealthy because they have a WXYfm score over 4. They combine this with a subsidy on healthy food which is either at the same rate as the VAT or at a higher rate which is designed to make the policy revenue neutral. Jensen and Smed (2007) also consider a variety of combinations of taxation and subsidy. In their case the fat tax is based on the amount of fat that is present in a particular food type and their subsidy is a either based on the amount of fibre in a product or a blanket reduction in VAT on fruit and vegetables.[3] Our approach combines aspects of both of these approaches. Like Jensen and Smed (2007), we vary the fat tax rate according to the fat content to assess whether this more targeted approach is more effective than that of Nnoaham et al. (2009) which has the merit of administrative simplicity. We increase the price of fatty foods by 1% for every percent of saturated fats they contain; for instance, milk which contains 1.72% of saturated fats will see its price increasing by 1.72%.[4] We put a ceiling on the price increase of 15%. To offset this tax burden and to encourage consumption of fruit and vegetables, a subsidy on fruit and vegetables is introduced, so as to exactly cancel the costs of the fat tax paid by consumers. Table 2

[Table 2 about here.]

presents the tax rates applied to the different food groups in our models, based on nutrient conversion tables available from the EFS data set. It can be seen

[3]VAT is not charged on fruit and vegetables in the UK at present.

[4]The saturated fat contents were obtained from data supplied in the Family Food module of the Expenditure and Food Survey. The majority of the data is from the Food Standards Agency's nutrient analysis programme, supplemented by values from manufacturers and retailers.

that there is considerable variation in the rates across different foods but in most cases the magnitude of the tax is in an area which, whilst not being popular, is likely to be acceptable.

Results[5]

Figures 1 and 2 show the impacts of the policy on nutrient intakes together with the maximum and minimum recommended daily amounts based on the sample of households that is used to estimate the model. In figure 1 it can be seen that current consumption levels of all fats and the components of total fats except for PUFAs all currently exceed the maximum daily amounts measured as a percentage of energy intake and whilst the tax reduces intakes it does not bring them in line with the recommendation. By contrast intakes of PUFAs are below the recommended amounts and since the tax reduces consumption marginally it is ineffective in helping to meet this target. Sugar consumption levels are also above the recommended amounts. The policy leads to a marginal increase in sugar consumption and there is therefore no impact in terms of this target either. In figure 2 the units differ between nutrients and are indicated with each column label. Figure 2 shows that the policy is effective in bringing fruit and vegetable consumption in line with the recommendations but it does not achieve this for sodium and fibre intakes.

[Table 3 about here.]

Table 3 shows the impacts on health that result from the dietary changes that are induced by the policy. As noted above, the figures reported in the before and after tax columns of the table measure the average odds of being affected by a condition across the population relative to a situation in which the whole population conforms to dietary guidelines. As an example, the figures show that average odds of being affected by CHD as a result of elevated intakes of saturated fatty acids are 78% higher than they would be if everyone ate in accordance with dietary guidelines. Following the introduction of our proposed fiscal intervention, the average odds fall but only to the point where they are 72% higher than if everyone satisfied the guidelines. This pattern is reproduced throughout the table, in general the policy is only marginally effective in reducing the average odds of being affected by a condition. Even in the case of fruit and vegetables, where we have seen that the average levels of consumption in the population are moved into the 'five-a-day' region, the average odds of being affected by conditions are only changed slightly by the policy. In particular, after the imposition of the tax, the average odds of being affected by the two cancers considered are still 26% and 12% higher than they would be if everybody ate 'five-a-day'. These relatively small changes in health status are understandable when, for example, it is recognised that the effect of the subsidy

[5] Full results for the econometric estimation of the models are available from the authors on request. Given their complexity, the models are robust with 67% of the estimated coefficients significant at the 95% level.

on fruit and vegetable consumption is to only reduce the proportion of the population that consumes less than 100g of fruit and vegetables per day from 13% to 12%. Thus, whilst mean levels of consumption are moved into line with the recommendations, a substantial part of the the population remains at a level of consumption which is a considerable distance from the guidelines.

Conclusion

The results show that a policy based on a tax on saturated fats coupled with a subsidy will be effective in moving diets in the UK in a direction consistent with improvements in diet related health. In particular a subsidy approaching 15% of the price of fruit and vegetables has been shown to be effective in moving the average intakes to within the recommended 'five-a-day' region. By contrast the fat tax does not result in intakes of fat moving to the recommended amounts. Importantly however, we have shown that although mean levels of consumption move favourably in comparison with guidelines a large proportion of the population will remain some considerable distance from the recommended levels of intake. As a result the average level of diet related disease risk does not change substantially in the population. Whilst we acknowledge that, because of the large numbers of people involved, even small changes in the level of risk may have a large impact on disease rates, the fact that considerable numbers of people will continue to consume particularly bad diets is likely to be of concern.

Our study contributes to the growing literature on the impacts of a fat tax on dietary choice and consequent effects on health. Our study adds an analysis which is based on a rigorous theoretically consistent econometric model of consumer demand and in which the analysis is conducted at the level of the individual household. It complements that of Nnoaham et al. (2009) who use elasticities from the National Food Survey (NFS; 2000) to simulate the impacts of a number of policy scenarios on food choice. Our study extends the number of foods that are explicitly modeled in the simulation and in particular allows for a disaggregation of milk and cream into categories which have differing levels of saturated fat. The importance of doing this is noted by (Andreyeva et al.; 2010) given the importance of milk as a source of saturated fat and the potential for reducing intakes by encouraging substitution between milk of differing fat contents. In a similar vein we also estimate separate elasticities for fresh potatoes, crisps and chips because of the implications of consuming each of these potato based foods for health. As a consequence of this greater degree of disaggregation, our policy scenario is differs from those examined by Nnoaham et al. (2009). Where they place VAT at 17.5% on either a subset of foods (milk, butter, cheese, biscuits, cakes and pastries) which are deemed to be high in saturated fats or those which are deemed to be unhealthy because they have a WXYfm score over 4, we charge a variable tax according to the fat content of the product. The result is that we have lower but differing rates of tax on milk (2.6%, 1.14% and 0.13% respectively on whole, semi skimmed and skimmed milk respectively). We therefore see a much greater decline in

consumption of whole milk (2.20%) than of skimmed milk (0.13%). It is not clear from the Nnoaham et al. (2009) paper how crisps are treated, however in our scenario the extremely high saturated fat content leads to a tax of 13.77% on these products and a resultant decline in consumption of 14.24%. Whilst it is not possible to perform a direct comparison between the impacts of the policies on saturated fat intakes between the two approaches,[6] the results we report suggest that the reduction of fat that results from our more targeted but less burdensome policy is broadly similar to that reported by Nnoaham et al. (2009). A final key difference in our analysis is that we do not have the anomalous situation where the elasticities between dairy products and fruit and vegetables indicate complementarity. This results in the Nnoaham et al. (2009) tax on dairy products having a negative impact on the consumption of fruit and vegetables, although this is effect is countered by the introduction of a fruit and vegetable subsidy. In our study, as a result of ensuring that the theoretical properties of the economic model of demand are satisfied, we have these products as substitutes. As a consequence the tax and subsidy act in the same direction to increase consumption of fruit and vegetables. We conclude that the beneficial health effects of policy induced increased fruit and vegetable consumption are likely to be understated by Nnoaham et al. (2009).

Our analysis is restricted in the sense that it focuses only on reducing saturated fat intakes and increasing fruit and vegetable consumption. Arguably, other aspects of nutrition are as important to target, in particular a policy may be based additionally on calorie, sugar and salt contents of foods. Our broad conclusion that a targeted policy is likely to bring significantly higher health benefits is likely to be equally applicable when considering a broader range of nutrients. We have argued that the model that is used to estimate the elasticities that form the basis of our simulations is consistent with an economic model of choice and that it therefore avoids the inconsistencies that in particular may have affected the cross-price elasticities that have been used in previous studies. A caveat to our model is that the data we employ does not have information on prices, we therefore use expenditure and quantity purchased to compute the unit value of the product that is purchased. The unit value also includes an element reflecting qualitative differences in the product and may also be endogenous to model. As a result differences in unit value may overstate the price difference that explains why differing quantitative decisions are taken and our elasticities may be underestimates. Furthermore, because the data that we use is cross-sectional, the ability of our model to capture temporal aspects of the response to taxes. In particular there is likely to be an element of persistence in peoples choices which is not reflected in our estimates. The adjustments which we simulate may therefore take some time to be realised.

A further important consideration is the differential impact that a fat tax will have across society. Other studies point out the regressive distributional impacts of the type of policy analysed here: because food represents a greater

[6] Our results are in terms of the proportion of energy derived from saturated fat, which declines by 2.00%, whilst Nnoaham et al. (2009) express theirs in the quantity of saturated fat which declines by 3.11%.

proportion of total household expenditure in poorer households, the burden of a tax on food will be fall disproportionately on the poor. Whilst combining the tax with a subsidy on fruit and vegetables serves to neutralise the impact of a tax in aggregate it is possible that it may add to the regressivity of the policy if fruit and vegetables a consumed in proportionately larger quantities in rich households. As Nnoaham et al. (2009) point out the regressivity might be justified if the health benefits accrue proportionately more to the poor. Low income households tend to consume poor diets, therefore the fact that the tax has a proportionately larger economic impact on these households is positive in targeting the most needy in terms of their dietary health. In spite of this however our analysis of the differential impacts of the policy across different demographic groups suggest that the effect of the policy on the risks of dietary disease are broadly similar across society (Arnoult et al.; 2008).

Our conclusion is that a fat tax should be seen as a component of a suite of instruments in tackling poor diets. Policies which target a number of different levels within society (eg. community, school, family, individual) referred to as social ecological approaches (Stokols et al.; 1996) are increasingly advocated as being more effective in delivering beneficial changes in diets (Gentile et al.; 2009). Experience in reducing the prevalence of smoking also points to an approach which does not rely entirely on price increases. (Levy et al.; 2007) find that 59% of the reduction in the prevalence of smoking in California is attributable to increases in price whilst 28% is attributable to media policies. Whilst fat taxes have the potential to effect marginal changes in the diets of large numbers of people, and thus have a significant impact on the incidence of disease across the population, more complex polices which target different levels in society are likely to be more effective in addressing the severe chronic dietary disease which affects some groups.

Conflicts of interest

We declare that we have no conflicts of interest

References

Andreyeva, T., Long, M. W. and Brownell, K. D. (2010). The impact of food prices on consumption: A systematic review of research on the price elasticity of demand fo food, *American Journal of Public Health* **100**: 216–222.

Arnoult, M., Tiffin, R. and Traill, W. (2008). Models of nutrient demand, tax policy and public health impact, Research Report, University of Reading.

Beecham, L. (2003). Doctors vote against a tax on fatty food, *British Medical Journal* **327**(7406): 72–l–.
URL: *http://www.bmj.com*

Blundell, R. and Meghir, C. (1987). Bivariate alternatives to the tobit-model, *Journal of Econometrics* **34**(1-2): 179 – 200.

Brownell, K. and Frieden, T. (2009). Ounces of prevention - the public policy case for taxes on sugared beverages, *New England Journal of Medicine* **360**(18).

Chouinard, H., Davis, D., LaFrance, J. and Perloff, J. (2005). The effects of a fat tax on dairy products, CUDARE Working Paper 1007, Department of Agricultural and Resource Economics, University of California,Berkeley, USA.

Deaton, A. and Muellbauer, J. (1980). An almost ideal demand system, *American Economic Review* **70**: 312–336.

DoH (1991). *Dietary Reference Values for Food Energy and Nutrients in the UK*, Vol. Report on Health and Social Subjects 41, Department of Health, London.

Edgerton, D. (1997). Weak seperability and the estimation of elasticities in multistage demandsystems, *American Journal of Agricultural Economics* **79**: 62–79.

Esrey, K., Joseph, L. and Grover, S. (1996). Relationships between dietary intake and coronary heart disease mortaility, *Journal of Clinical Epidemiology* **49**(2): 211–216.

Food Standards Agency (2007). *Low Income Diet and Nutrition Survey*, The Stationary Office.

Gentile, D., Walk, G., Eisenmann, J., Reimer, R., Walsh, D., Russell, D., Callahan, R., Walsh, M., Strickland, S. and Fritz, K. (2009). Evaluation of a multiple ecological level child obesity prevention program: Switch what you do, view and chew, *BMC Medicine* **7**.

Hung, H., Joshipura, K., Jiang, R., Hu, F., andS.A. Smith-Warner, D. H., Colditz, G., Rosner, B. and andW.C. Willett, D. S. (2004). Fruit and vegetable intake and risk of major chronic disease, *Journal of the National Cancer Institute* **96**(21): 1577–1584.

Jensen, J. and Smed, S. (2007). Cost-effective design of economic instruments in nutrition policy, *International Journal of Behavioral Nutrition and Physical Activity* **4**(10).

Joshipura, K., Hu, F., Manson, J., Stampfer, M., Speizer, E. R. F., Colditz, G., Ascherio, A., Rosner, B. and Willett, D. S. W. (2001). The effect of fruit and vegetable intake on risk for coronary heart disease, *Annals of Internal Medicine* **134**(12): 1106–1114.

Kennedy, E. and Offutt, S. (2000). Alternative nutrition outcome using a fiscal food policy. commentary tomarshall (2000), *British Medical Journal* **320**(7230): 304–305.

Kuchler, F., Tegene, A. and Harris, J. (2005). Taxing snack foods: Manipulating diet quality or financing information programs?, *Review of Agricultural Economics* **27**(1): 4–20.

Levy, D., Hyland, A., Higbee, C., Remer, L. and Compton, C. (2007). The role of public policies in reducing smoking prevalence in california: Results from the california tobacco policy simulation model, *Helath Policy* **82**: 167–185.

Marshall, T. (2000). Exploring a fiscal food policy: The case of diet and ischaemic heart disease, *British Medical Journal* **320**(7230): 301–304.

Mytton, O., Gray, A., Rayner, M. and Rutter, H. (2007). Could targeted food taxes improve health?, *Journal of Epidemiology and Community Health* **61**(8): 689–694.

NFS (2000). National food survey. Date accessed 13/07/2010.
URL: *http://www.defra.gov.uk/evidence/statistics/foodfarm/food/familyfood/nationalfoodsurvey/documents/NFS2000.pdf*

Nnoaham, K., Sacks, G., Rayner, M., Mytton, O. and Gray, A. (2009). Modelling income group differences in the health and economic impacts of targeted food taxes and subsidies, *International Journal of Epidemiology* **38**: 1324–1333.

Riboli, E. and Norat, T. (2003). Epidemiologic evidence of the protective effect of fruit and vegetableson cancer risk, *American Journal of Clinical Nutrition* **78**(3S): 559S–569S.

Stokols, D., Allen, J. and Bellingham, R. (1996). The social ecology of health promotion: Implications for research and practice, *American Journal of Health Promotion* **10**: 247–51.

Tiffin, R. and Arnoult, M. (2008). Bayesian estimation of the infrequency of purchase model with an application to food demand in the uk.
URL: *http://mpra.ub.uni-muenchen.de/18836/*

List of figures

List of Tables

Table 1: Food Categories

Grouping	Obs	Component Foods
Milk	6315	Whole Milk
		Semi-skimmed Milk
		Skimmed Milk
Other Dairy, Eggs and Fats	6687	Cheese and Cream
		Other Dairy
		Eggs
		Fats
Meat and Fish	6588	Beef
		Lamb
		Pork
		Poultry
		Fish
		Other
Potatoes, Rice and Pasta	6262	Fresh potatoes
		Crisps
		Chips
		Rice and Pasta
Cereals	6784	Bread
		Breakfast Cereals
		Other Cereals
		Confectionery
Fruit and Vegetables	6588	Fresh
		Frozen
		Tinned
		Prepared
		Ready Meals
Drinks	6414	Tea and Coffee
		Soft Drinks
		Alcohol

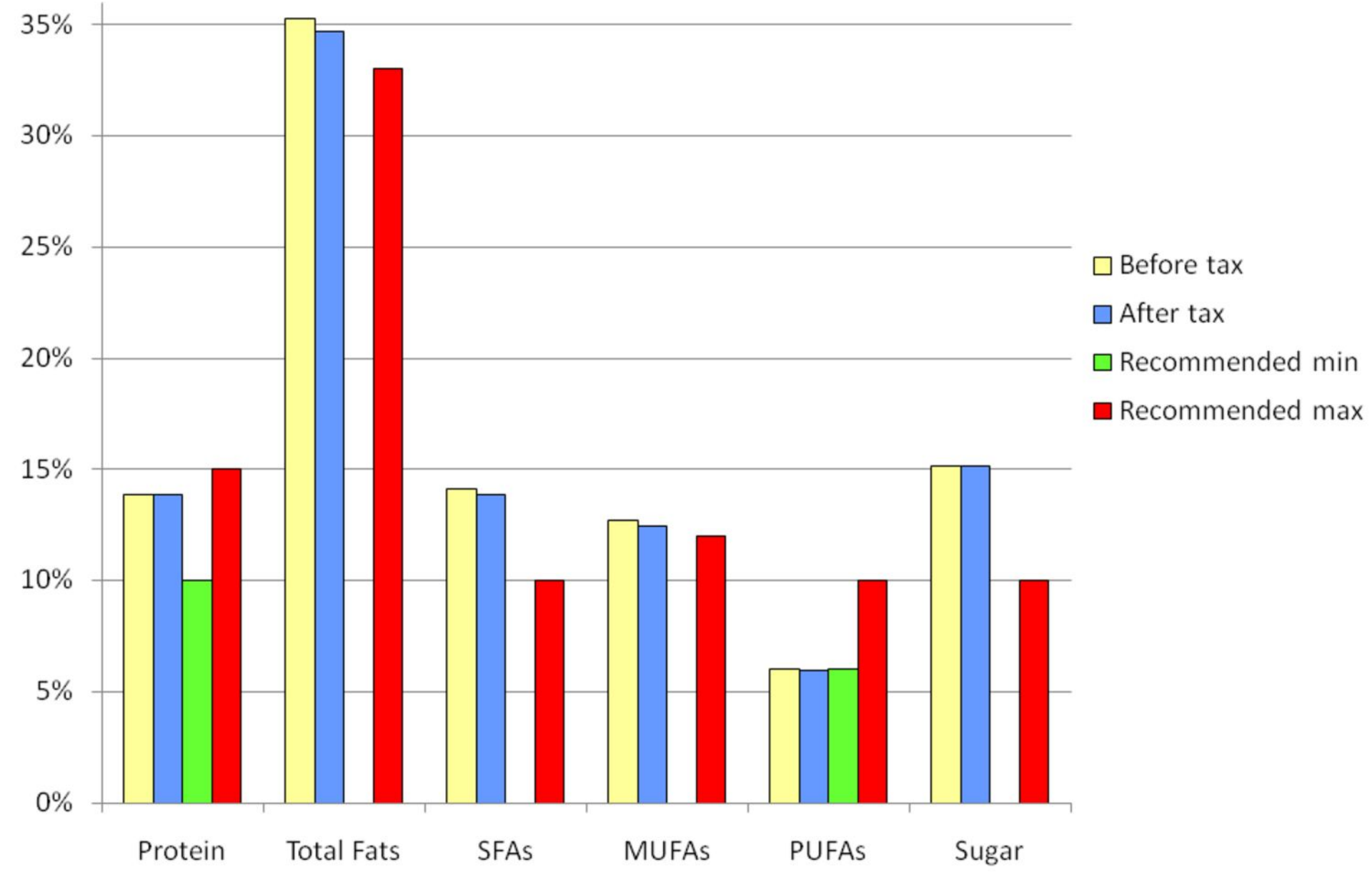
Table 2: Tax and subsidy rates used in the simulation

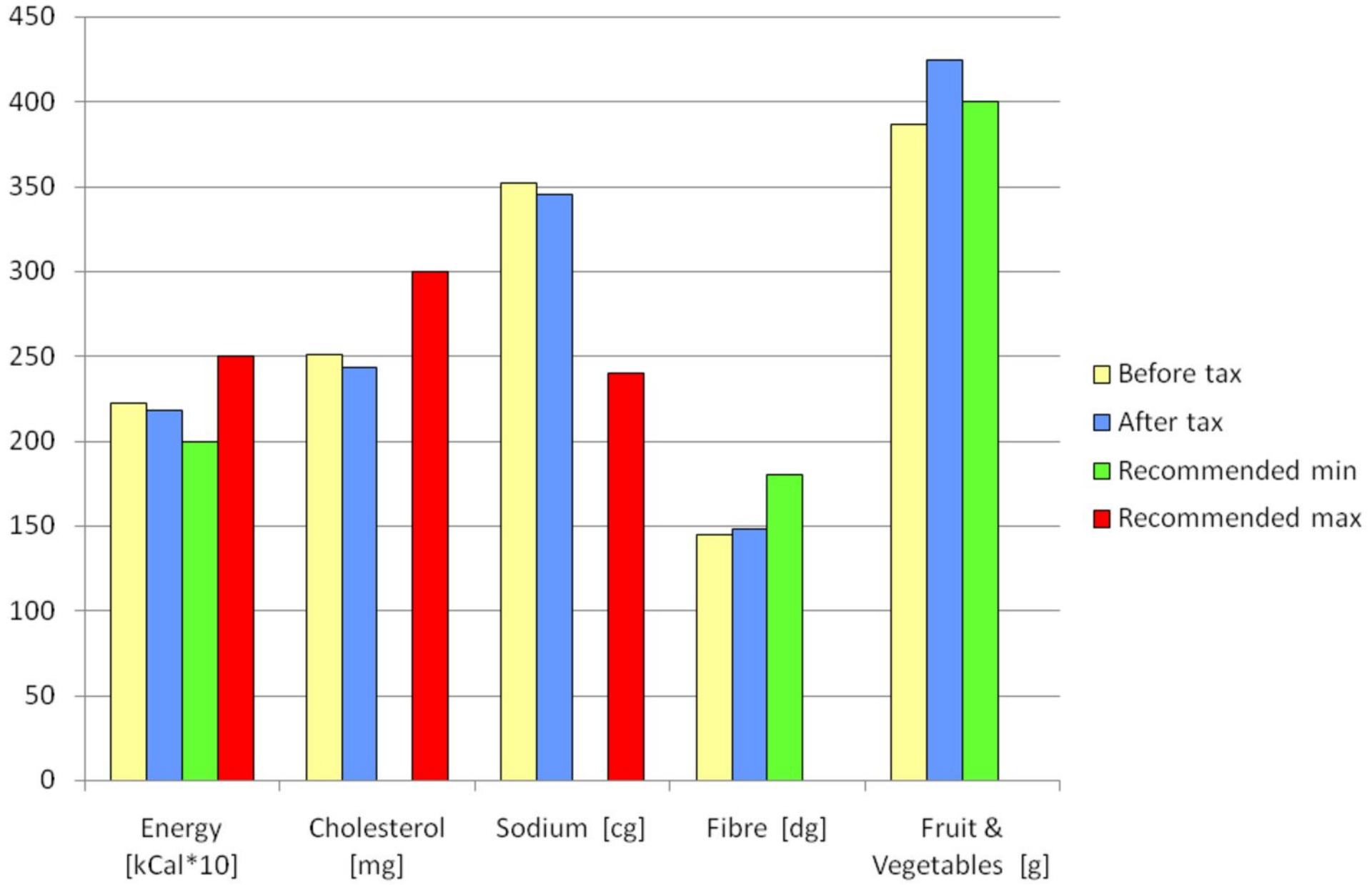
Food	Tax
Full Fat Milk	2.60%
Semi Skimmed Milk	1.14%
Skimmed Milk	0.13%
Cheese and Cream	15.00%
Other dairy	2.83%
Eggs	3.20%
Fats	15.00%
Beef	5.98%
Lamb	6.38%
Pork	4.55%
Poultry	1.93%
Fish	1.58%
Other	5.40%
Fresh Potatoes	1.16%
Chips	1.55%
Crisps	13.77%
Rice and Pasta	0.31%
Bread	0.58%
Breakfast cereals	0.88%
Other cereals	4.75%
Confectionery	5.94%
Fresh Fruit and Vegetables	-14.78%
Frozen Fruit and Vegetables	-14.78%
Tinned Fruit and Vegetables	-14.78%
Prepared Fruit and Vegetables	-14.78%
Fruit and Vegetables based Ready Meals	2.27%
Tea and Coffee	0.55%
Soft drinks	0.00%
Alcohol	0.01%

Table 3: Impacts on health

	Condition[1]	Before tax	After tax
Totals fats	CHD [4]	1.18	1.15
SFA	CHD [4]	1.78	1.72
MUFA	CHD [4]	1.14	1.12
PUFA	CHD [4]	1.02	1.02
Fruit and Vegetables	gastric cancer [1]	1.34	1.27
	lung cancer [1]	1.16	1.12
	CVD [2]	1.18	1.13
	CHD [3]	1.04	1.02
	chronic disease [2]	1.04	1.02
	ischemic stroke [3]	1.06	1.04

[1] The figures in parenthesis indicate the source of the relative risk estimates as follows: [1] Riboli and Norat (2003); [2] Hung et al. (2004); [3] Joshipura et al. (2001); [4] Esrey et al. (1996).


35%
30%
25%
20%
15%
10%
5%
0%
Protein
Total Fats
SFAs
MUFAs
PUFAs
Sugar
Before tax
After tax
Recommended min
Recommended max


450
400
350
300
250
200
150
100
50
0
Energy [kCal*10]
Cholesterol [mg]
Sodium [cg]
Fibre [dg]
Fruit & Vegetables [g]
Before tax
After tax
Recommended min
Recommended max