The Distributional Consequences of a Fiscal Food Policy: Evidence From the UK

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Abstract

The extant literature on fat taxes and thin subsidies tends to focus on the overall effectiveness of such fiscal instruments in altering diets and improving health. However, little is known about the welfare impacts of fiscal food policies on society. This paper fills a gap in the literature by assessing the distributional impacts and welfare effects resulting from a tax-subsidy combination on different food groups. Using the methods derived from marginal tax reform theory, a formal welfare economics framework is developed allowing the calculation of the distributional characteristics of various food groups and approximate welfare measures of prices changes caused by a tax-subsidy combination. The distributional characteristics reveal that many of the food groups targeted by a fat tax are consumed in greater concentration by low-income households than higher-income households. The overall welfare effect of a fat tax in isolation is found to be negative. While the inclusion of a thin subsidy still results in welfare losses, the negative impact of the fat tax is mostly mitigated by the presence of the thin subsidy. Results suggest there is scope for the design of a fiscal food policy to combat obesity and poor dietary choice that is both revenue neutral and welfare minimising.

JEL Codes: D30, D60, H20, I10, I30.
Keywords: distributional characteristic, economic welfare, fat tax, indirect tax reform, obesity, thin subsidy.

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1 Introduction

One of the most pressing public health challenges today is the prevalence of diet related chronic disease resulting from poor dietary choices, specifically overweight and obesity. According to the 2004 Health Survey for England, which records body mass index (BMI), nearly 65% of the adult population were overweight (BMI greater than 25) while almost 25% were obese (BMI greater than 30). A great deal of interest and attention is focused on the use of fiscal interventions to combat spiralling obesity rates, both in the United Kingdom and in the United States. Much of the work to date on fat taxes and thin subsidies focuses on their overall effectiveness to reduce unhealthy food consumption and reduce obesity rates. While many of the studies conducted by economists tend to show only a slight decrease in fat consumption resulting from a fat tax (Chouinard et. al 2007; Powell and Chaloupka 2009), studies by health professionals show that fat taxes have meaningful impacts through reduced rates of cardiovascular disease (Marshall 2000; Mytton et. al 2007). For example, Mytton et. al (2007) show that up to 3200 deaths from cardiovascular disease could be avoided in the UK through a fat tax on a wide range of foods, and Marshall (2000) demonstrates that a tax on dietary saturated fat could avert up to 1000 deaths a year in the UK.

Despite the attention on the use of fat taxes and thin subsidies as a method of regulating diets and improving health, very little is known about the expected impacts such policies will have on the welfare of the population as a whole. How much redistribution will be achieved by implementing a combination of taxes and subsidies on various food groups? Will the proposed fiscal interventions harm consumers in terms of social welfare? How much of the welfare change may be attributed to fat taxes, and how much of this damage can be compensated by the use of subsidies? These questions are addressed using the tax reform methodology developed by Feldstein (1972) and Stern (1987) to examine the distributional consequences and welfare implications of fat taxes and thin subsidies on food consumption.[1] Addressing the welfare implications of a fat tax is not as clear as it might initially seem however. Drenowski (2004) finds that obesity and type 2 diabetes follow a socioeconomic gradient in the U.S. in which the highest rates of disease are found among groups with the highest poverty rates and the least education. An obvious explanation is found in Dowler's (2003) concept of "food poverty" where in developed countries a pattern exists with households living on low wages have lower nutrient intakes and worse dietary patterns than households in a better economic position.

From a classical welfare economics perspective, taxing foods will be highly regressive on low income households, especially when the tax is targeted on energy-dense, nutrient-poor, fatty foods which are disproportionately consumed in low income households. However, from a public health perspective, taxing

[1] For summaries see Atkinson and Stiglitz (1980), Stern and Newbery (1987), and Santoro (2007). For applications see Ahmad and Stern (1984), Newbery (1995), Ray (1999), Liberati (2001), and Kaplanoglou (2004).

unhealthy foods will reduce diet related chronic diseases, increase nutrient intakes, and improve dietary patterns, particularly in the low income households. The extent to which a thin subsidy mitigates these effects is uncertain and largely depends on demand behaviour. Consequently, a fat tax will have a negative welfare effect in terms of regressive *wealth* redistribution, however such a policy will also have a positive welfare effect in terms of progressive *health* redistribution. In short, there is a health-wealth trade-off to a fiscal food policy. Depending on the responsiveness of consumers to price changes in different food groups, a thin subsidy may alleviate (and possibly outweigh) the negative welfare impact of a fat tax. Moreover, the thin subsidy may reinforce the health improvements of a fat tax by increasing consumption of healthier foods. The overall welfare impact and the distributional consequences of a combined fiscal policy of a fat tax and thin subsidy is the focus of this paper. The distributional consequences are assessed using the distributional characteristic derived by Feldstein (1972) while the welfare impacts are measured using the method presented in Stern (1987) and Newbery (1995).

This paper is organised as follows. A brief review of the literature is in section 2, with an emphasis on the welfare effects of fiscal food policies. Section 3 describes the theoretical and empirical methodology. The data are described in section 4, as well as the empirical results. The final section concludes.

2 Fiscal food policies and social welfare

There is a growing literature investigating the effects of fat taxes and more recently thin subsidies. Much of the research emphasises health outcomes and focuses on the effectiveness of fiscal food interventions in reducing diet related chronic disease, such as obesity. However, no known study examines the welfare effects of fat taxes (and none in regards to thin subsidies) in a rigorous economic framework. The few studies that in fact address distributional concerns do not do so within a true social welfare context. When considering tax reform and the welfare effect of changes in relative prices, like the proposed changes in food prices from a combination of taxes and subsidies, analysis that follows from a formal social welfare theory framework provides theoretical advantages and also provides limits on the necessary assumptions about the data (Ahmad and Stern 1984).

First, informal welfare measures of social welfare, such as money-metric measures like equivalent and compensating variation, are far from ideal. Money metric utility measures assume by definition that the social marginal utility of income is equal to one in every household (Banks, Blundell, and Lewbel 1996). As is discussed in the next section, this is a limiting assumption worth relaxing since it does not allow distributional judgements. Moreover, Blackorby and Donaldson (1988) show that money metric measures violate concavity of social orderings over optimal commodity allocations unless household preferences are homothetic.[2] Thus, while data requirements tend to be modest for money-metric measures, they only represent valid measures of welfare under very strict assumptions which are not normally descriptive of actual behaviour (Blackorby and Donaldson 1988). Second, considerations of distributional equity can only be assessed under a rigorous social welfare model, which allows the social marginal utility of income to differ between households and permits social judgements on equality. By specifying a social welfare function with heterogeneous marginal utilities, not only can welfare impacts due to price changes be assessed, but distributional implications can be analysed using the distributional characteristic. The distributional characteristic gives a measure of the concentration of consumption in low income households for a set of commodities and allows the analyst to see which price changes resulting from a tax will have a greater impact on poor or rich households (Feldstein 1972). Hence, the distributional characteristic allows a policy-maker to appropriately target commodity groups for taxes and subsidies and is a powerful tool in applied welfare economics. However, unlike money-metric measures, the distributional characteristic requires a formal social welfare framework with a well-defined social welfare function and so accounts for social preferences.

Leicester and Windmeijer (2004) simulate a fat tax in the UK and assess the distributional effects. In their simulation, food was taxed based on four nutrients found to have adverse health consequences when consumed in large quantities (saturated fat, mono-unsaturated fat, sodium, and cholesterol). The tax was assessed at the rate of one pence per a kilogramme of the nutrient. Based on the simulated tax rate and using data from the 2000 National Food Survey, the fat tax is found to be highly regressive. The poorest 2% of the 8000 household sample spend 0.7% of their income on the tax, while the richest pay only 0.1% (the median income group pay about 0.25%). However, the welfare analysis in Leicester and Windmeijer (2004) is very limiting. First, the calculations do not account for the potentially offsetting impact of subsidies. Second, the calculations do not allow for consumers to shift consumption in the event of a price change. Third, the analysis is not based on a formal social welfare framework.

Chouinard et. al (2007) examine the welfare effects of a fat tax on various dairy products using a unique micro-data set on weekly average household purchases for a sample of 23 US cities. They simulate the effects of a fat tax based on the fat percentage of different dairy products. Based on a 10% tax rate, they calculate the equivalent variation as a measure of the welfare loss resulting from the tax. Their results find the fat tax to be highly regressive, with the burden falling mostly on the low-income households: the burden is 0.24% for households with an annual income of $20,000 USD, but only 0.024% for households with an annual income of $100,000 USD. While the analysis in Chouinard et. al (2007) uses demand elasticities and represents an

[2] Assuming homothetic preferences implies that an individual income consumption curve is linear over the whole consumption set, which represents a critical flaw for applied welfare analysis. See Blackorby and Donaldson (1988) for a theoretical proof.

improvement over the analysis in Leicester and Windmeijer (2004), there remain key limitations. First, the framework in Chouinard et. al (2007) is limited to dairy products and the elasticities computed in their paper do not account for the full range of substitutability across different groups of goods. Furthermore, as already discussed, the use of equivalent variation is open to a range of problems and is widely accepted to be a poor welfare measure (Slesnick 1998).

Allais et. al (2010) conduct an analysis similar to Chouinard et. al (2007) except they estimate the demand elasticities for a full range of food groups for a sample of French households using the TNS Worldpanel survey. Simulating a 10% tax on foods in the cheese and butter category they find the tax regressive as well: the burden is 0.22% for modest income households but only 0.068% for well-off households. However, their analysis suffers from similar flaws mentioned above since the welfare calculations are based on equivalent variation and do not examine the impact of subsidies. Although elementary in their welfare analysis, the papers by Leicester and Windmeijer (2004), Chouinard et. al (2007), and Allais et. al (2010) represent the only attempt in the literature to investigate the welfare effects of fat taxes. To be fair, the focus of each of these papers is not on social welfare but rather on the effectiveness of fat taxes in changing diets and improving health, which is generally the focus of all research regarding fat taxes and thin subsidies.

While the impact on health from fiscal food policies is an important area of study, little to nothing is known about the impact on social welfare resulting from a combination of fat taxes and thin subsidies. This paper examines the impact of fat taxes and thin subsides within a formal and rigorous welfare economics framework. The analysis provides two distinct economic measures of welfare. First, the distributional characteristic is computed providing information on the degree of concentration of different food items in low income households and makes clear the extent to which taxes and subsidies will impact the poor. Second, first-order and second-order welfare measure approximations are calculated to assess the overall impact of fat taxes and thin subsidies on social welfare. The next section derives each of these measures and provides an intuitive interpretation of both the distributional characteristic and welfare approximations in the context of fiscal food policies.

3 The welfare impact of price changes

The method employed in this paper is based on the theory of marginal tax reform and normative optimal taxation theory. The theory originates with Feldstein (1972) and Ahmad and Stern (1984) and is based on the optimal commodity taxation rules derived by Ramsey (1927) and Samuelson (1986). Good summaries are found in Atkinson and Stiglitz (1980), Newbery and Stern (1987), and Santoro (2007). In this method, a set of indirect tax policies are judged based on their distributional impact within a utilitarian social welfare framework. Two aspects of a change in price are being assessed. First, the redistributive effect of the price change is gauged through the calculation of the distributional characteristic for a set of disaggregate goods. Second, the overall impact of the price change on social welfare is assessed using an approximate measure of welfare.

The starting point is the social welfare function, which aggregates individual welfare levels. Define the social welfare function over $h = 1, \ldots, H$ households[3]

$$W = W\left(U^1, \ldots, U^H\right) = W\left(V^1\left(e^1, p\right), \ldots, V^H\left(e^H, p\right)\right), \tag{1}$$

where for household h, U^h is the direct utility function and is equivalent to the indirect utility function $V^h\left(e^h, p\right)$, which is a function of household expenditures, e^h and a vector of prices, p.[4] Note that the household consumes a number of goods, where $i = 1, \ldots, G$ and each household is assumed to face the same set of prices. The social welfare function in equation 1 is of the Bergson-Samuelson class, in which society's welfare is a function only of the individual utilities of its members (Bergson 1938, Samuelson 1956).

Consider a marginal change in the consumer price of good i from p_i to $p_i^\star$, where $p_i^\star = p_i + \Delta p_i$ and Δp_i is the marginal price change. The impact on social welfare, W, from a marginal change in consumer price is

$$\frac{\Delta W}{\Delta p_i} = \frac{W^\star\left(V^1\left(e^1, p^\star\right), \ldots, V^H\left(e^H, p^\star\right)\right) - W\left(V^1\left(e^1, p\right), \ldots, V^H\left(e^H, p\right)\right)}{\Delta p_i}, \tag{2}$$

where $W^\star$ is social welfare at the changed price and W is social welfare at the original price. The first step in examining the welfare impact of a price change, such as one resulting from a fat tax or thin subsidy, is to approximate the effect in equation 2. To gauge the distributional consequences of a price change on food expenditure, the distributional characteristic is computed. Attention now turns to the derivation of the distributional characteristic, followed by the derivation of the approximate welfare measure.

3.1 The distributional characteristic

Feldstein (1972) introduces the concept of the distributional characteristic of a good as a way of explicitly considering the distributional equity of optimal prices and taxes. By considering not just efficiency but also equity, the distributional characteristic represents a value judgement. The distributional characteristic is commonly used to examine distributional consequences from indirect taxes and price changes (See, for

[3] Given that household expenditure data is used in the welfare analysis, the relevant unit of measure in this paper is the household rather than the individual agent. See Slesnick (1998, p. 2123 - 2125) for a discussion on the justifications and limitations of modelling the household as the decision-making unit.

[4] Indirect utility is a function of expenditure rather than income in the welfare analysis. Slesnick (1998, p. 2146) states that "in a static context the appropriate welfare indicator should be a function of total expenditure rather than income," therefore expenditure can be taken as a proxy for income.

example, Newbery (1995), Ray (1999), and Liberati (2001)).[5] In the context of a fiscal food policy, changes in food prices can have implications for the distribution of income, especially since the poor tend to spend a disproportionately large share of income on food-related items. The distributional characteristic measures the extent consumption of a good (such as chips or fresh fruit) is distributed across the distribution of income (or expenditure). The key advantage of computing the distributional characteristic is that it provides information on the distributional impacts of indirect price changes, like those caused by fat taxes and thin subsidies, by showing what price changes in goods will impact the less well-off the most. With the distributional characteristic, the policy-maker is equipped with a tool to aid in targeting decisions of indirect taxes and subsidies.

The approach is based on that pioneered by Bergson (1937) and Samuelson (1947). Before deriving the distributional characteristic, first consider the impact on social welfare from a change in household expenditure

$$\beta^h \equiv \frac{\partial W\left(V^1\left(e^1,p\right),\ldots,V^H\left(e^H,p\right)\right)}{\partial V^h\left(e^h,p\right)}\cdot\frac{\partial V^h\left(e^h,p\right)}{\partial e^h}=\frac{\partial W}{\partial V^h}\cdot\alpha^h, \tag{3}$$

where α^h is the private marginal utility of expenditure (or income). The value of β^h is the social weight or the social marginal utility of household h receiving an additional unit of expenditure (Newbery 1995) and it therefore combines the weighting of the policy maker or social planner $\frac{\partial W}{\partial V^h}$ with that of the private individual, α^h.[6] More simply, β^h represents society's valuation of one additional unit of expenditure given to household h. The distributional value judgements of the policy maker determine the form of the social welfare function in equation (Mas-Colell, Whinston, and Green 1995). In practise the form chosen is typically the additive utilitarian form where $W=\sum_h V^h$, which implies that the social weights β^h for each household equal the private marginal utility of income, α^h. The form chosen for the indirect utility function is usually the isoelastic form whose marginal utilities have constant elasticity. This is discussed in more detail in section 3.3.

The distributional characteristic is used to measure the extent to which consumption of a particular good is concentrated in those households which are deemed to be socially deserving where "socially deserving" is recognised by those households with higher values of β^h. This is achieved by constructing a measure in which the consumption of the i^{th} good by the h^{th} household $\left(q_i^h\right)$ with its marginal social utility and aggregating

[5] Previous studies tend to use the distributional characteristic in an ex post fashion in which the welfare impact of price changes that have already occurred is being analysed. The use of the distributional characteristic in this paper is ex ante, that is, the welfare impact of price changes that *may* occur is being analysed. This is similar in spirit to the problem investigated in Banks, Blundell, and Lewbel (1996) who suppose a hypothetical price change on clothing to assess first-order and second-order welfare approximations.

[6] Feldstein (1972) defines the marginal social utility of income as the derivative of the social welfare function with respect to household income.

across households. Thus, following Newbery (1995), the distributional characteristic, d_i, for the i^{th} good is

$$d_i \equiv \frac{\sum_h^H \beta^h q_i^h}{\overline{\beta} Q_i}, \tag{4}$$

where $\overline{\beta} \equiv \frac{1}{H}\sum_h^H \beta^h$ is the average of the social utility weights over all households and $Q_i \equiv \sum_h^H q_i^h$ is aggregate consumption of the i^{th} good.[7] The measure is unit free, given the normalisation of the individual household social weight (β^h) by the overall average social weight ($\overline{\beta}$), and is bounded between zero and one. In terms of price changes, the distributional characteristic is interpreted as a measure of the relative harm/benefit of placing a tax/subsidy on the i^{th} good relative to the harm/benefit of placing a tax/subsidy on all households directly (Kaplanoglou 2004).

We compute the distributional characteristic for different food groups (milk, cheese, pork, fresh fruits and vegetables, tinned fruit and vegetables, etc). This will reveal if consumption of certain food groups are distributed to the socially deserving or not. The higher the value of d_i, the more concentrated the consumption of the food group on the more socially deserving households. A typical welfare framework would imply that food groups with a low d_i should be taxed while food groups with a high d_i should be subsidised. In a social welfare context, any tax on the food group with a relatively high distributional characteristic will be highly regressive if evaluated against income or total expenditure. However, from a public health perspective the implications are different. Given the extant literature, high distributional characteristics are likely to be found for energy-dense, nutrient-poor, fatty foods (e.g., pre-packaged ready made meals), which tend to be less expensive than healthier, low calorie, nutrient-rich foods (e.g., fresh fruits and vegetables) per calorie (Dowler 2003; Drenowski 2004; Frazao et. al 2007). Consumption of fatty and sugary foods contributes to a range of public health problems, such as diabetes and heart disease, and so the use of fiscal instruments has been debated as a means of shifting consumption towards healthier choices.

In this paper, the distributional characteristics reveal the extent to which consumption of unhealthy foods (e.g., fats and cheeses) is concentrated in the "socially deserving" (i.e., low-income households) and the extent to which consumption of healthy foods (e.g., fresh fruits and vegetables) is concentrated in the "socially undeserving" (i.e., high-income households). If this is the case, then from a public health perspective unhealthy foods should be taxed while healthy foods should be subsidised to improve the distribution of health among low-income households. However, from a social welfare perspective the opposite could be true: unhealthy foods should be subsidised while healthy foods should be taxed. If the distributional characteristics reveal that consumption of unhealthy foods are not concentrated in low-income households, then a fat tax appears more attractive both from an economic welfare perspective and a public health perspective. While obviously

[7] The numerator of the distributional characteristic is actually the absolute impact of a price change on social welfare, which is derived in the next section.

still regressive on low-income households, the negative welfare effect of the fat tax may be compensated for by a thin subsidy on healthier food options. The direction of the welfare effect, in terms of income changes, is approximated by the welfare measures derived in the next section.

3.2 Welfare approximation

While computation of the distributional characteristics discussed in the previous section is important for summarising the distributional impact of fat taxes and thin subsidies, it does not address the aggregate change in social welfare. Measures that approximate the effect in equation 2, that is the impact on welfare from a change in price, are used to gauge aggregate welfare effects. First-order welfare approximations, which have the notable advantage of not requiring information on consumer demand behaviour, are discussed first. Second-order welfare approximations, which extend the first-order approximation to account for possible shifts in consumption resulting from price changes, are then explained.

3.2.1 First order approximation

As a starting point, suppose the the price of good i increases through a marginal change in the tax rate. In money terms, household h is worse by the quantity consumed, q_i^h, or in utility terms is worse off by $\alpha^h \cdot q_i^h$ (Ahmad and Stern 1984). Using Roy's identity the change in household utility from a price change is given by

$$\frac{\partial V^h}{\partial p_i} = -\frac{\partial V^h}{\partial e^h} \cdot q_i^h = -\alpha^h q_i^h. \tag{5}$$

The change in social utility for a small change in price (e.g., a tax or subsidy on quantities) in equation 2 can be approximated to provide a numerical measure of the change in social welfare. The first-order welfare approximation of the effect of a small change in price (of good i) is given by

$$\frac{\Delta W}{\Delta p_i} \approx \frac{\partial W}{\partial p_i} = \sum_h^H \frac{\partial W\left(V^1\left(e^1, p\right), \ldots, V^H\left(e^H, p\right)\right)}{\partial V^h\left(e^h, p\right)} \cdot \frac{\partial V^h}{\partial p_i}. \tag{6}$$

Using equation 5 and social welfare function in equation 1, the level form of the first-order approximation is obtained

$$\frac{\Delta W}{\Delta p_i} \approx \frac{\partial W}{\partial p_i} = -\sum_h^H \beta^h q_i^h. \tag{7}$$

From the first-order approximation in equation 7, the welfare impact of a price change is seen to depend on two factors: the distribution of consumption, given by the social weights β^h, and the level of consumption among households, given by q_i^h (Newbery 1995). The first-order welfare measure in equation 8 expresses the idea that if the marginal price paid for good i changes through either a tax or a subsidy, then the welfare loss or gain to the household depends upon the current expenditure by the household on the i^{th} good. In the context of fat taxes and thin subsidies, suppose a government policy proposes a tax (subsidy) on food group i totalling £1 across all households. An alternative to the fiscal policy proposal would be to apply the tax (subsidy) directly on all households so that each household's income is taxed (subsidised) in the amount of $\frac{1}{H}$£1. The tax (subsidy) on the good is preferred, by the social planner, over the direct tax (subsidy) only when household expenditure on good i is below (above) the average household (Alan et. al 2002).

The approximate welfare change resulting from a marginal change in price of the i^{th} good is found by summing the social marginal utilities of income, β^h, weighted by consumption of good i over all households.[8] Alternatively, the first-order approximation can be written in terms of the distributional characteristic

$$\Delta W = -\overline{\beta} d_i Q_i \Delta p_i, \tag{8}$$

since the numerator of the distributional characteristic defined in equation 4 is equal to the welfare approximation in equation 7 (Newbery 1995). The relevance of the distributional characteristic to the welfare effects of price changes is made more clear in the approximation given by equation 8. When a price increase occurs for a good whose consumption is concentrated in households with high marginal utilities of expenditure (i.e., low-income or socially deserving households), the price increase will have a more negative impact than if the price increase occurred on a good whose consumption is concentrated in households with low marginal utilities of expenditure (i.e., high-income households). Given that price changes may occur over the spectrum of goods consumed, the effect on social welfare from multiple price changes is

$$\Delta W = -\sum_i^G \overline{\beta} d_i Q_i \Delta p_i, \tag{9}$$

An expression for the proportional change in social welfare resulting from changes in prices is obtained by normalising equation 9 by the initial level of welfare

$$\frac{\Delta W}{W} = -\frac{\sum_i d_i Q_i \Delta p_i}{\sum_i d_i Q_i p_i}. \tag{10}$$

Equation 10 measures the proportional impact of price changes on aggregate social welfare and is interpreted

[8] Implicitly producer prices are assumed fixed so the change in price on good i is equivalent to the tax on that good. While the assumption simplifies distributional issues and serves as an appropriate benchmark, tax over-shifting is a possibility (Liberati 2001).

as the percent change in welfare caused by a change in price.

3.2.2 Second order approximation

While the first-order welfare approximation has the advantage of limited data requirements, since only knowledge of expenditure is required, it may also be a biased estimate. The first-order approximation does not account for changes in consumption in response to price changes, thus it may overestimate the welfare impact of a price increase from a tax or underestimate the welfare impact of a price decrease from a subsidy. Banks, Blundell, and Lewbel (1996) provide a second-order approximation of equation 2 using a Taylor expansion

$$\frac{\Delta W}{\Delta p_i} \approx \frac{\partial W}{\partial p_i} + \frac{\Delta p_i}{2} \cdot \frac{\partial^2 W}{\partial p_i^2}. \tag{11}$$

Given that the derivative of the first order approximation by p_i is

$$\frac{\partial^2 W}{\partial p_i^2} = -\sum_h \left(\frac{\partial \beta^h}{\partial p_i} \cdot q_i^h + \frac{\partial q_i^h}{\partial p_i} \cdot \beta^h \right) \tag{12}$$

The second order approximation in equation 11 can be written as

$$\frac{\Delta W}{\Delta p_i} \approx -\sum_h^H \beta^h q_i^h \left[1 + \frac{\Delta p_i}{2p_i} \left(\frac{\partial \beta^h}{\partial p_i} \cdot \frac{p_i}{q_i^h} + \frac{\partial q_i^h}{\partial p_i} \cdot \frac{p_i}{\beta^h} \right) \right] \tag{13}$$

or equivalently as

$$\frac{\Delta W}{\Delta p_i} \approx -\sum_h^H \beta^h q_i^h \left[1 + \frac{\Delta p_i}{2p_i} \left(\epsilon_{\beta^h}^h + \epsilon_{ii}^h \right) \right], \tag{14}$$

where, for each household, $\epsilon_{\beta^h}^h$ is the price elasticity of the welfare weight defined in equation 3, while ϵ_{ii}^h is the own price elasticity of demand (i.e., the uncompensated Marshallian demand elasticity). The quality of the second-order approximation (and the first-order) largely depends on the responsiveness of β^h and q^h to prices (Banks, Blundell, and Lewbel 1996). Since the additional term in the second-order approximation is negative, the first-order approximation will generally overstate the social welfare effect of a price change from a tax (or understate the effect from a subsidy). Note that the partial derivatives in equation 13 are evaluated at the original pre-tax/subsidy prices, hence the price elasticities in equation 14 are also based on original prices. Given that the second-order approximation is a function of the price elasticities of demand, estimation of a complete demand system is necessary to obtain the estimated elasticities needed for the computation in equation 13.

Generally, to obtain a more manageable expression, the additional assumption is made that the welfare weights are invariant to prices, implying that $\epsilon^h_{\beta^h}$ is zero.[9] Making this assumption and substituting in the distributional characteristics, the second-order welfare approximation is

$$\frac{\Delta W}{\Delta p_i} \approx -\overline{\beta} \sum_i^G d_i Q_i \left[1 + \frac{\Delta p_i}{2p_i} \cdot \epsilon^h_{ii}\right] \tag{15}$$

where the summation over i indicates multiple price changes. Likewise, a second order expression for the proportional change in welfare resulting from changes in prices is

$$\Delta W \approx -\frac{\sum_i d_i Q_i \left[1 + \frac{\Delta p_i}{2p_i} \cdot \epsilon^h_{ii}\right] \Delta p_i}{\sum_i d_i Q_i \left[1 + \frac{1}{2} \cdot \epsilon^h_{ii}\right] p_i} \tag{16}$$

which shares a similar interpretation as the percent change in welfare caused by a change in price. However, the second order proportional approximation in equation 16 is more accurate than the first order proportional approximation in equation 10 since it accounts for changes in quantity demand.

3.3 Implementation

To make the welfare approach operational, knowledge of two components is required: household expenditure on a set of goods and the ability to determine socially deserving households. Expenditure data is easily obtained from household budget surveys. The social weights, β^h, provide the ability to identify households more deserving of marginal increases in income. To calculate the social weights, the social welfare function must first be given a functional form.

An additive social welfare function based on individual isoelastic utility functions, originally proposed by Atkinson (1970), is the most frequently used social welfare function in the marginal indirect taxation literature (see, for example, Ahmad and Stern (1984), Madden (1995a), Madden (1995b), Newbery (1995), and Banks, Blundell, and Lewbel (1996)) and is formally represented by

$$W = \sum_h V^h. \tag{17}$$

Indirect utility is defined over real expenditure (consumption) per equivalent adult, E^h, and is parametrised as

$$\begin{array}{ll} V^h = k\,(1-\rho)^{-1}\left(E^h\right)^{1-\rho} & \rho \neq 1 \\ V^h = k \ln E^h & \rho = 1 \end{array}, \tag{18}$$

where $\rho \geq 0$ is the coefficient of inequality aversion. The social welfare function is more egalitarian with

[9] The assumption of price invariant welfare weights is made in nearly all applied welfare analyses, though the restrictiveness of this assumption is discussed in Roberts (1980), Slivinski (1983), and Banks, Blundell, and Lewbel (1996). See Ray (1999) for an empirical application in which in the welfare weights are taken to be a function of prices.

greater values of ρ. Thus, under additive social preferences, social welfare is approximated by the weighted sum of expenditures per equivalent adult.[10] The indirect utility function, V^h, is in the family of isoelastic utility functions where the marginal utilities have constant elasticity. The parameter k is chosen to normalise the welfare weight. Typically, k is chosen to assign a social weight equal to unity for either the household with the lowest expenditure or the household with average expenditure. Given the functional form in equation 18, the social weights (i.e., marginal social utility) are

$$\beta^h \equiv \frac{\partial W}{\partial V^h} \cdot \frac{\partial V^h}{\partial e^h} = \left(\frac{E^h}{E^1}\right)^{-\rho}, \tag{19}$$

where social weight of 1 is being applied to the poorest household (i.e., the household with the smallest expenditure per equivalent adult). Therefore, following Ahmad and Stern (1984), β^h is interpreted as the marginal social value of an additional unit of expenditure to household h relative to the poorest household. In this case, from the point of view of the social planner, marginal increases in expenditure to the low income households are more valuable than the same increase to a higher income household.

The inequality aversion parameter determines the extent to which a marginal increase in expenditure to the poor is worth more than to the rich. In particular, the social value of a marginal unit of income to the poorest household is worth 2^ρ times as much to a household with twice the income. Thus, values of ρ that are successively greater than zero lead to greater weight being applied to poorer households. By increasing the value of the coefficient of inequality aversion, ρ, the relative weight given to consumption of low-income households in the distributional characteristic (i.e., β^h) is also increased. In other words, different values of ρ lead to different judgements regarding income transfers. For example, suppose Household A has half the income of Household B. If $\rho = 1$, a marginal unit of income has twice as much social value when transferred to Household A rather than Household B. If $\rho = 2$, a marginal unit of income has quadruple the social value when transferred to Household A. The precise definition of the social welfare weights in equation 19 depends upon the specification of the social welfare function and the indirect utility function.

The additive social welfare function in equation 17 based on the isoelastic indirect utility function in equation 18 is one example of a generalised utilitarian social welfare function (i.e., $W = \sum_h \mathcal{F}\left(V^h\right)$,where $\mathcal{F}(\bullet)$ is an increasing, concave function) in which the welfare weights only depend on the expenditure level and are independent of prices.[11] In this framework, the social planner makes an intentional decision or social judgement to weight household utility differentially based on the socially deserving. The isoelastic form is

[10] Total expenditure on all goods in each household is divided by the number of equivalent adults in each household to obtain expenditure per equivalent adult. The actual number of equivalent adults are obtained using the OECD equivalence scales, which counts the first adult in the household as one "full" person. Additional adults count as 0.7 and children under the age of 14 count as 0.5.

[11] Banks, Blundell, and Lewbel (1996) discuss the drawbacks associate with assuming price-independent social weights.

convenient since the coefficient of inequality aversion has an intuitive meaning: a one percent decrease in income (or expenditure) implies a ρ percent increase in marginal social utility (Feldstein 1972). The isoelastic utility function is also convenient in the context of indirect tax reform because assumptions about inequality can be adjusted by means of a single parameter (Mas-Colell, Whinston, and Green 1995).[12] At one extreme end when $\rho = 0$ then $W = \sum V^h$ is the Benthamian pure utilitarian case of no inequality aversion and β^h collapses to unity meaning all households are applied the same social weight so distributional issues are of no concern. In the Benthamian case, the social planner views a unit increase in expenditure to the poorest household to be worth the same as a unit increase to the richest. In the pure utilitarian case, increases and decreases in individual household utility imply a one-for-one change in social utility, and is often referred to as the linear-in-utility welfare function since the indifference curves are linear (Varian 1992). At the other extreme when $\rho \to \infty$ then $W = \min\left\{V^1, \ldots, V^H\right\}$ is the Rawlsian maximin case in which only the utility of the poorest household matters (i.e., the utility of the household with the lowest consumption or expenditure). In the maximin case all the social weight is applied to worst-off household and the indifference curves are lexicographic or L-shaped (Mas-Colell, Whinston, and Green 1995). A range of values for ρ are used in the empirical analysis to see if conclusions are robust to different distributional judgements.

4 Data and Food Groups

Data on food expenditures and quantities are from the UK government's Expenditure and Food Survey (EFS) for 2003-2004, which records data on a wide range of food eaten. The EFS (starting in 2001-2002) is the result of the merger between the Family Expenditure Survey (FES) and the National Food Survey (NFS), two well established surveys and important sources of information for government and the broad research community on UK spending and food consumption patterns. In this study we use the 2003-2004 data-set, which is the latest (at the time of starting to work with the data) complete data set available from the Economic and Social Data Service (ESDS). The 2003-2004 sample is based on 7,014 households in 672 postcode sectors stratified by Government Office Region in England and Wales. Participating households voluntarily record food purchases for consumption at home for a two week period using a food diary for each individual over seven years of age. The data collected by the food diaries are supplemented with the use of till receipts.

The EFS identifies four major categories of interest: food (sub-divided in 55 categories), non-alcoholic drink (sub-divided in 7 groups), alcoholic drink (sub-divided in 4 groups) and catering services (split into 3 categories). In addition to data on food expenditure and quantity, other key variables are available,

[12] While most welfare studies on indirect taxes and price changes utilise the isoelastic form, other function forms can be used. Cragg (1991), for example, uses the Kolm-Pollak utility function.

including: ownership of food-related durables (fridges, freezers etc.), housing tenure, key demographics (age, sex, employment status etc.) for each household member, type and composition, social class of head of household, region and categorical degree of activity for head of household (i.e. sedentary, active etc.). While information is collected on eating out expenditure, food eaten out of the home is omitted from the analysis since no data on quantities is provided. The data extracted from the EFS are prepared into a form suitable for welfare calculation.

Individual food items and farm commodities are converted into aggregate food groups that can be identified for a fat tax or thin subsidy. Five main food group aggregations are used in the analysis: dairy, eggs, and fats; meat and fish, cereals and potatoes; fruits and vegetables; and drinks. A sixth category of "other foods" is used to categorise those component food items that do not clearly fit into the other five categories.[13] Each of the main food groups are composed of component food item groups (25 in total), which are detailed in the first two columns of Table 1. While such broad aggregates simplifies the analysis, detailed information is inevitably lost in the aggregation process. For example, the "milk" category includes both full-fat and skimmed milk, and the distributional characteristics may potentially differ between these two sub-category items. Table 1 also presents the sample means and standard deviations of quantities consumed and expenditures for the component food group items. In regards to units, mean quantities consumed per household are in kilogrammes or litre equivalent and expenditure per household is in pounds GBP per kilogramme or litre equivalent. Table 2 presents the sample means and standard deviations of budget shares for both the primary food groups and the component food items. The groups "meat and fish" and "cereals and potatoes" on average compose the largest share of household budgets, followed by fruits and vegetables, beverages, and dairy products. However, given the magnitude of the standard deviations, clearly households differ quite widely in terms of which component food groups compose a greater or lesser share of the household food budget.

The fat tax applied to selected food groups is based on saturated fatty acids, while the subsidy is applied to fruit & vegetables. The fiscal policy used, based on a combination of taxes and subsidies, is designed to be a revenue-neutral scheme. The choice of saturated fatty acids as the prime target of the fat tax is justified by evidence from the medical literature. Saturated fats are an important risk factor in the occurrence of coronary heart disease (Hu et al. 1997), higher systolic blood pressure (Esrey et al. 1996), and higher plasma concentration of cholesterol (Ascherio et al. 1994). Fruit and vegetables, on the other hand, are positively linked to lower risks of various cancers (Ames et al. 1995; Riboli and Norat 2003), major chronic diseases (Hung et al. 2001), and ischaemic stroke (Joshipura et al. 2001). Specifically, the fiscal scheme simulation

[13] The exact food group items that compose each of the component food groups is available in an appendix upon request to the author

increases the price of each food group by 1% for every percent of saturated fats the group contains. The EFS data set contains nutrient conversion tables that are used to convert food group items into nutrient content. For example, since milk contains 1.72% of saturated fats, its price increasing by 1.72%. A ceiling of 15% is placed on the simulated price increase. To offset this tax burden, and to encourage the 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 3 presents the tax and subsidy rates applied to the different component food group items and assigns an index number to each group. Table 3 also presents the own price (uncompensated) elasticities for each of the component food groups.[14] These elasticities are used in the second order welfare approximation.

5 Results

Recall from section 3.1 that the distributional characteristic of a good is a measure of the relationship between a household's consumption of a good and the marginal value of a change in household income. The distributional characteristic is a scale free measure, between zero and one, with values closer to one indicating that consumption of a particular good is concentrated in poor households. Tax receipts will be disproportionately paid by lower-income households the larger the distributional characteristic of a good. A subsidy on a good with a smaller distributional characteristic will be disproportionately paid to higher income households. Subsequently, from an economic welfare viewpoint, goods with larger distributional characteristic ought to be subsidised while goods with a smaller distributional characteristics ought to be taxed. Table 4 presents the distributional characteristics of the component food items in descending order as well as the rank order of the commodities. The distributional characteristics are calculated based on different values of the inequality aversion coefficient reflecting low ($\rho = 0.5$), moderate ($\rho = 1.0, 1.5$), and high ($\rho = 2.0$) inequality aversion.

Generally, the four food groups with the highest ranking (i.e., the highest distributional characteristics), reflecting expenditure being concentrated amongst households with high marginal utilities of expenditure (i.e., low-income households) are milk, bread, eggs, and potatoes, rice, and pasta. Although when $\rho = 2.0$, the fats food group replaces potatoes, rice and pasta in ranking as the fourth highest and potatoes, rice, and pasta drop in ranking to sixth. The four food groups with the lowest ranking, reflecting expenditure being concentrated in the higher income households are alcohol, lamb, fruit and vegetable ready-based meals, and fish, which is consistent throughout the different values of inequality aversion. In between the two extremes the rankings of food items do not remain constant but shifts, meaning the relative rankings of the

[14] The estimated Marshallian demand elasticities are obtained from a companion paper. See Tiffin (2009) for more information.

different foods groups changes. Table 4 also shows that in many instances the distributional characteristics are very close in value for some goods. For example, when $\rho = 1.0$, tea and coffee, fats, breakfast cereal, and confectionery have distributional characteristics that are very close. Overall, results show minor variation in the value of the distributional characteristics over the food groups considered for the different values of inequality aversion. For example, when $\rho = 1.0$, the distributional characteristics are all greater than 0.5, meaning food consumption is relatively concentrated in the socially deserving households.

Suppose the distributional characteristics under each value of inequality aversion are split into a top half and bottom half, say at the 13^{th} ranking, for example. Of the fruit and vegetable groups marked for subsidy (fresh, frozen, tinned, prepared, and ready meals), both frozen and tinned fruits and vegetables consistently place in the top half (amongst those groups most concentrated in poor households) whilst fresh, prepared and ready-meal fruit and vegetables consistently place in the bottom half. Moreover, the fats food group (which has the heaviest tax rate) consistently places amongst the food items that are more heavily concentrated in the socially deserving households. Interestingly, the cheeses and creams group, which also has the heaviest tax rate, is consistently found in the bottom half. According to the distributional characteristics in Table 4, a welfare enhancing policy prescription would be to tax the food items with the lowest distributional characteristics while subsidising the foods with the highest distributional characteristics. However, according to the fiscal policy scheme implemented with the intention of inducing healthier diets, the foods with the highest distributional characteristics are all targeted for fat taxes. While policy guided by public health concerns may desire higher prices in food groups such as fats and lower prices in fresh fruits and vegetables, a policy guided by economic welfare considerations would suggest a subsidy on fats and a tax fresh fruits and vegetables.

While the distributional characteristics suggest that a fat tax policy will disproportionately burden low-income households, the welfare approximation in equation 10 is calculated to provide a measure of the overall impact on welfare as a result of the fiscal policy. Given that there is a possibility that the thin subsidy may offset the negative welfare impacts of the fat tax, the welfare measure yields the percent change in welfare caused by the simulated price change. Table 5 reports the results of computing the first order approximation in equation 10 and the second order approximation in equation 16 for the fiscal policy described in Table 3 over different values of inequality aversion.

Referring to the first order approximations, while the percent changes in welfare are small, the overall impact on social welfare from the fiscal policy is slightly negative. Moreover, the negative changes in welfare are increasing in the level of aversion to inequality, which implies that the fiscal policy has redistributive effect that is more adverse to low-income households than higher income households. The relatively small impact is not surprising, given that food represents just one of many different consumption bundles in the overall basket of goods consumed by households. The second order approximations are very close in magnitude to the first order approximations, suggesting that the first order approximation error is quite small. Moreover, the second order approximations are smaller than the first order counterparts (consistent with theory), but still remain slightly negative. This implies that while the fiscal policy used in the simulation is revenue neutral, there is a very small decrease in social welfare. To see the extent to which the thin subsidies mitigate the fat tax, the welfare measures are recomputed except with the absence of subsidies on fruit and vegetables. The results, as presented in Table 3 are revealing. In the absence of the thin subsidy, welfare drops by nearly three percent across all values of inequality aversion. Additionally, the negative welfare impact of a fat tax in the absence of thin subsidy is nearly four times that than when a subsidy is also in place. This welfare impact is viewed as a loss in consumer income or expenditure with respect to the household food budget. As such, a three percent drop is arguably a non-trivial drop in welfare. This outcome is important as it suggests that while a fat tax alone is likely to be regressive and will disproportionately hurt low-income households, thin subsidies remain a useful policy tool that will mitigate the welfare losses that arise from the use of a fat tax in isolation.

6 Summary

Obesity is of increasing concern throughout the developed world. Some estimates suggest that by 2015, 60% of men and 50% of women will be obese. Being obese increases the risks of a range of chronic health problems including heart disease, type 2 diabetes and high blood pressure. Additionally it has been shown that increased levels of fruit and vegetable consumption will contribute to a reduction in the incidence of some cancers. As a result, there is an increase in interest in public health policies that are designed to reduce the impacts of diet related disease. One such policy is a fiscal intervention designed to reduce the consumption of calorie and fat dense food and to encourage the consumption of fruit and vegetables. There is a trade-off between health and wealth from imposing a fat tax on society. In terms of public health, taxing unhealthy, fatty foods is likely to have a positive health effect as consumers shift their distribution of consumption to healthier food choices. However, in terms of social welfare, since consumption of fatty and calorie dense foods tends to be concentrated in low income households, a fat tax is likely to extremely regressive. This paper fills a knowledge gap by focusing on the redistribution of income resulting from a tax-subsidy combination on different food groups. Further, unlike previous studies, this paper uses a formal welfare economics framework to assess the welfare implications of a combination of fat taxes and thin subsidies.

This paper examines the distributional consequences and economic welfare impacts of such a policy. The study finds that there is a trade-off between public health and economic welfare from imposing a fat tax on society. Energy-dense/nutrient-poor foods are disproportionately consumed among low-income households, which are the foods most likely to be taxed by a "fat tax" policy. Thus, fiscal interventions can have adverse welfare implications for the very population it is intended to benefit. This paper shows that this is indeed the case, that food is a distribution ally sensitive item in the household budget. Results also indicate that the consumption of food groups marked for taxes tends to be concentrated in the socially deserving households. The welfare analysis shows that a fat tax applied alone will be regressive and will have a substantially negative impact on welfare. However, a thin subsidy can mitigate the welfare losses to a large extent. Therefore, in terms of a fiscal food policy designed to combat obesity and promote healthy eating, such a policy ought to include both fat taxes and thin subsidies.

References

[1] Alan, S., T.F. Crossley, P. Grootendorst, and M.R. Veall. (2002). The effects of drug subsidies on out-of-pocket prescription drug expenditures by seniors: regional evidence from Canada. *Journal of Health Economics*, 21(5): 805-826

[2] Allais, O., P. Bertail, and V. Nichèle (2010). The effect of a fat tax on French households' purchases: a nutritional approach. *American Journal of Agricultural Economics*, 92(1): 228-245.

[3] Ahmad, E., and N. Stern. (1984). The theory of reform and Indian indirect taxes. *Journal of Public Economics*, 25(3): 259-298.

[4] Ames, B.N., and L.S. Gold, and W.C. Willett. (1995). The causes and prevention of cancer. *Proceedings of the National Academy of Sciences*, 92(12): 5258-5265.

[5] Ascherio, A., C.H. Hennekens, J.E. Buring, C. Master, M.J. Stampfer, and W.C. Willet. (1994). Trans-fatty acids intake and risk of myocardial infarction. *Circulation*, 89(1): 94-101.

[6] Atkinson, A.B. (1970). On the measurement of inequality. *Journal of Economic Theory*, 2(3): 244-263.

[7] Atkinson, A.B., and J.E. Stiglitz. (1980). *Lectures on Public Economics*. McGraw-Hill: Maidenhead, UK.

[8] Banks, J., R. Blundell, and A. Lewbel. (1996). Tax reform and welfare measurement: do we need demand system estimation? *Economic Journal*, 106(438): 1227-1241.

[9] Blackorby, C., and D. Donaldson. (1988). Money-metric utility: a harmless normalisation? *Journal of Economic Theory*, 46(1): 120-129.

[10] Bergson, A. (1938). A reformulation of certain aspects of welfare economics. *Quarterly Journal of Economics*, 52(2): 310-334.

[11] Chouinard, H.H., D.E. Davis, J.T. LaFrance, and J.M. Perloff. (2007). Fat taxes: big money for small change. *Forum for Health Economics & Policy*, 10(2): Berkeley Electronic Press.

[12] Cragg, M. (1991). Do we care? A study of Canada's indirect tax system. *Canadian Journal of Economics*, 24(1): 124-143.

[13] Deaton, A., and J. Muellbauer. (1980). *Economics and Consumer Demand*. Cambridge University Press: Cambridge, UK.

[14] Esrey, K. L. Joseph, and S. Glover. (1996). Relationships between dietary intake and coronary heart disease mortality. *Journal of Clinical Epidemiology*, 49(2): 211-216.

[15] Feldstein, M.S. (1972). Distributional equity and the optimal structure of public prices. *American Economic Review*, 62(1-2): 32-36.

[16] Frazao, E., M. Andrews, D. Smallwood, and M. Prell. (2007). Food spending patterns of low-income households: will increasing purchasing power result in healthier food choices? In *Can Food Stamps Do More to Improve Food Choices? An Economic Perspective*, Economic Information Bulletin Number 29-4. Washington, DC: US Department of Agriculture, Economic Research Service.

[17] Hu, F., M.J. Stampfer, E. Rimm, G. Colditz, B. Rosner, C.H. Hennekens, and D. Willett. (1997). Dietary fat intake and the risk of coronary heart disease in women. *New England Journal of Medicine*, 337(21): 1491-1499.

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

[19] Joshipura, , F. Hu, J. Manson, M. Stampfer, R. Rimm, F. Speizer, G. Colditz, A. Ascherio, B. Rosner, D. Spiegelman, and D. Willett. (2001). The effect of fruit and vegetable intake on risk of coronary heart disease. *Annals of Internal Medicine*, 134(12): 1106-1114.

[20] Kaplanoglou, G. (2004). Household consumption patterns, indirect tax structures and implications for indirect tax harmonisation: a three country perspective. *Economic and Social Review*, 35(1): 83-107.

[21] Leicester, A., and F. Windmeijer. (2004). The "fat tax": economic incentives to reduce obesity. Briefing Note No. 49, Institute for Fiscal Studies: London, UK.

[22] Liberati, P. (2001). The distributional effects of indirect tax changes in Italy. *International Tax and Public Finance*, 8(1): 27-51.

[23] Madden, D. (1995). Labour supply, commodity demand, and marginal tax reform. *Economic Journal*, 105(429): 485-497.

[24] Madden, D. (1995). An analysis of indirect tax reform in Ireland in the 1980s. *Fiscal Studies*, 16(2): 18-37.

[25] Marshall, T. (2000). Exploring a fiscal food policy: the case of diet and ischaemic heart disease. *British Medical Journal*, 320(7230): 301-305.

[26] Mas-Colell, A., M.D. Whinston, and J.R. Green. (1995). *Microeconomic Theory*. Oxford University Press: New York, NY.

[27] Mayshar, J., and S. Yitzhaki. (1995). Dalton-improving indirect tax reform. *American Economic Review*, 85(4): 793-807.

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

[29] Newbery, D.M. (1995). The distributional impact of price changes in Hungary and the United Kingdom. *Economic Journal*, 105(431): 847-863.

[30] Newbery, D.M., and N. Stern (1987). *The Theory of Taxation for Developing Countries*. Oxford University Press for the World Bank: Oxford, UK.

[31] Powell, L.M., and F.J. Chaloupka. (2009). Food prices and obesity: evidence and policy implications for taxes and subsidies. *Milbank Quarterly*, 87(1): 229-257.

[32] Ramsey, F.P. (1927). A contribution to the theory of taxation. *Economic Journal*, 37(145): 47-61.

[33] Ray, R. (1999). Marginal and non-marginal commodity tax reforms with rank two and rank three demographic demand systems. *Oxford Economic Papers*, 51(4): 689-712.

[34] Riboli, E., and T. Norat. (2003). Epidemiologic evidence of the protective effect of fruit and vegetables on cancer risk. *American Journal of Clinical Nutrition*, 78(3S): 559S-569S.

[35] Roberts, K. (1980). Price-independent welfare prescriptions. *Journal of Public Economics*, 13(3): 277-98.

[36] Samuelson, P.A. (1956). Social indifference curves. *Quarterly Journal of Economics*, 70(1): 1-22.

[37] Samuelson, P.A. (1986). Theory of optimal taxation. *Journal of Public Economics*, 30(2): 137-143.

[38] Santoro, A. (2007). Marginal commodity tax reforms: a survey. *Journal of Economic Surveys*, 21(4): 827-848.

[39] Slesnick, D.T. (1998). Empirical approaches to the measurement of welfare. *Journal of Economic Literature*, 36(4): 2108-2165.

[40] Slivinski, X.X. (1983). Income distribution and the law of one price. *Journal of Public Economics*, 20(1): 103-112.

[41] Stern, N. (1987). The theory of optimal commodity and income taxation. In *The Theory of Taxation for Developing Countries* (ed. D. Newbery and N. Stern). Oxford University Press: Oxford, UK.

[42] Tiffin, R. (2009). The demand for a healthy diet: microeconometrics and metabolic syndrome. Working paper, Department of Agricultural and Food Economics, The University of Reading, UK.

[43] Tiffin, R., and M.A. Arnoult. (2009). The public health impacts of a fat tax. Working paper, Department of Agricultural and Food Economics, The University of Reading, UK.

Main Food Groups	Component Foods	Quantity		Expenditure	
Dairy, Eggs, & Fats	Milk	8.46	(7.59)	0.45	(0.44)
	Cheese & cream	0.58	(0.67)	0.27	(0.31)
	Other dairy	2.22	(2.67)	0.41	(0.45)
	Eggs	0.01	(0.01)	0.08	(0.11)
	Fats	1.03	(1.21)	0.22	(0.24)
Meat & Fish	Beef	0.76	(1.13)	0.35	(0.57)
	Lamb	0.24	(0.98)	0.13	(0.39)
	Pork	0.84	(1.07)	0.46	(0.52)
	Poultry	1.18	(1.70)	0.45	(0.58)
	Fish	0.72	(1.09)	0.44	(0.61)
	Other meats	2.07	(2.07)	0.98	(1.05)
Cereals & Potatoes	Potatoes, rice, & pasta	2.09	(2.81)	0.53	(0.57)
	Breads	3.84	(3.12)	0.46	(0.39)
	Breakfast cereals	0.72	(0.96)	0.20	(0.26)
	Other cereals	0.73	(0.90)	0.38	(0.55)
	Confectionery	3.44	(2.83)	1.17	(1.06)
Fruit & Vegetables	Fresh fruit & vegetables	6.87	(6.01)	1.07	(1.02)
	Frozen fruit & vegetables	0.36	(0.80)	0.05	(0.11)
	Tinned fruit & vegetables	2.86	(3.48)	0.30	(0.37)
	Prepared fruit & vegetables	0.61	(1.01)	0.14	(0.21)
	Fruit & vegetable based meals	0.29	(0.52)	0.12	(0.24)
Beverages	Tea & coffee	0.26	(0.36	0.19	(0.26)
	Soft drinks	10.57	(13.22)	0.45	(0.54)
	Alcohol	3.67	(6.95)	1.23	(2.20)

Table 1: Food groups

Table 2: Total expenditure shares

Main Food Groups	Component Foods	Budget Share	
Dairy, Eggs, & Fats	Milk	0.053	(0.057)
	Cheese & cream	0.026	(0.028
	Other dairy	0.039	(0.039
	Eggs	0.009	(0.015)
	Fats	0.022	(0.026)
	Total dairy, eggs, & fats share	0.149	
Meat & Fish	Beef	0.032	(0.047)
	Lamb	0.011	(0.032)
	Pork	0.045	(0.046)
	Poultry	0.041	(0.047)
	Fish	0.042	(0.051)
	Other meats	0.094	(0.085)
	Total meat & fish share	0.265	
Cereals & Potatoes	Potatoes, rice, & pasta	0.049	(0.046)
	Breads	0.049	(0.042)
	Breakfast cereals	0.020	(0.027)
	Other cereals	0.035	(0.053)
	Confectionery	0.113	(0.080)
	Total cereals & potatoes share	0.266	
Fruit & Vegetables	Fresh fruit & vegetables	0.104	(0.081)
	Frozen fruit & vegetables	0.005	(0.012)
	Tinned fruit & vegetables	0.028	(0.033)
	Prepared fruit & vegetables	0.014	(0.021)
	Fruit & vegetable based meals	0.011	(0.023)
	Total fruit and vegetable share	0.162	
Beverages	Tea & coffee	0.021	(0.031)
	Soft drinks	0.041	(0.046)
	Alcohol	0.096	(0.139)
	Total beverage share	0.158	

Table 3: Fiscal food policy

Index Number	Component Foods	Tax / Subsidy	Elasticity
1	Milk	1.46%	-0.187
2	Cheese & cream	15.00%	-0.508
3	Other dairy	2.83%	-0.428
4	Eggs	3.20%	-0.710
5	Fats	15.00%	-0.518
6	Beef	5.98%	-0.744
7	Lamb	6.38%	-0.901
8	Pork	4.55%	-0.675
9	Poultry	1.93%	-0.920
10	Fish	1.58%	-0.512
11	Other meats	5.40%	-0.846
12	Potatoes, rice, & pasta	1.16%	-0.594
13	Breads	0.58%	-0.350
14	Breakfast cereals	0.88%	-0.686
15	Other cereals	4.75%	-0.796
16	Confectionery	5.94%	-0.531
17	Fresh fruit & vegetables	-14.78%	-0.846
18	Frozen fruit & vegetables	-14.78%	-0.832
19	Tinned fruit & vegetables	-14.78%	-0.780
20	Prepared fruit & vegetables	-14.78%	-0.769
21	Fruit & vegetable based meals	2.27%	-0.853
22	Tea & coffee	0.55%	-0.783
23	Soft drinks	0.00%	-0.825
24	Alcohol	0.01%	-0.931

Table 4: Distributional characteristics of food groups

	Social weight based on:							
	$\rho = 0.5$		$\rho = 1.0$		$\rho = 1.5$		$\rho = 2.0$	
rank	d_i	index	d_i	index	d_i	index	d_i	index
1	0.941	1	0.827	1	0.582	1	0.274	1
2	0.928	13	0.803	13	0.543	13	0.204	13
3	0.914	4	0.778	4	0.517	4	0.190	4
4	0.908	12	0.759	12	0.479	12	0.159	5
5	0.903	22	0.752	22	0.478	5	0.156	22
6	0.903	14	0.752	5	0.476	22	0.154	12
7	0.902	5	0.749	14	0.469	14	0.150	16
8	0.900	16	0.744	16	0.465	16	0.149	14
9	0.896	18	0.735	18	0.456	23	0.145	23
10	0.895	23	0.735	23	0.453	18	0.143	19
11	0.894	11	0.732	11	0.449	11	0.140	18
12	0.889	15	0.724	19	0.448	19	0.137	11
13	0.887	19	0.724	15	0.441	15	0.137	17
14	0.886	3	0.717	3	0.435	3	0.137	6
15	0.877	17	0.709	17	0.434	6	0.134	15
16	0.877	6	0.708	6	0.434	17	0.132	3
17	0.874	20	0.702	20	0.427	20	0.132	20
18	0.873	8	0.701	2	0.424	2	0.129	2
19	0.873	2	0.697	8	0.421	9	0.128	9
20	0.870	9	0.697	9	0.416	8	0.124	8
21	0.869	10	0.693	10	0.414	10	0.123	10
22	0.867	21	0.688	21	0.409	21	0.122	21
23	0.838	7	0.645	7	0.372	7	0.107	7
24	0.806	24	0.596	24	0.330	24	0.092	24

Table 5: Welfare effect of fiscal policy

	Tax/Subsidy Policy		Tax Only Policy	
	1st Order	2nd Order	1st Order	2nd Oder
$\rho = 0$	-0.76%	-0.56%	-2.89%	-2.83%
$\rho = 0.5$	-0.79%	-0.60%	-2.92%	-2.86%
$\rho = 1.0$	-0.81%	-0.62%	-2.94%	-2.88%
$\rho = 1.5$	-0.83%	-0.64%	-2.95%	-2.89%
$\rho = 2.0$	-0.84%	-0.65%	-2.93%	-2.86%
$\rho = 5.0$	-1.46%	-1.45%	-1.48%	-1.48%