Could foods High in Fat, Sugar and Salt (HFSS) taxes improve Climate Health and Nutrition in Scotland?

Amaracchi Nneli[1], Wisdom Dogbe[2] & Cesar Revoredo-Giha[3]

A Paper Presented at the AES Annual Conference 2022

The University of Warwick, Coventry,

27–29 March 2022

[1] School of Geosciences, University of Edinburgh, Edinburgh. Email: A.E.Nneli@sms.ed.ac.uk
[2] The Rowett Institute, University of Aberdeen, Foresterhill, Aberdeen AB25 2ZD, United Kingdom. Email: wisdom.dogbe@abdn.ac.uk
[3] Scotland's Rural College (SRUC), Peter Wilson Building, King's Buildings, West Mains Road, Edinburgh EH9 3JG, United Kingdom

Abstract

Foods high in fats, sugar and salt (HFSS) have huge impact on public health, climate health, and the economy. As such, it is critical to ascertain how pricing policies could help reduce their consumption in Scotland. This study analysed a secondary data of 3,260 households from Kantar Worldpanel which comprised of eighteen food categories consumed in Scotland. The primary objective is to simulate the implications of an excise tax imposed on HFSS on food purchases, climate health and consumer welfare using uncompensated own and cross price elasticities estimated from the Exact Affine Stone Index demand model. Two policy scenarios were considered: taxing all HFSS whilst the prices of the remaining foods remained unchanged; and taxing HFSS whilst subsidizing fruit and vegetables with the revenue generated. Results from the study indicate that imposing taxes on HFSS would reduce their consumption due to price effects. Also, a 10 percent tax on HFSS food groups while subsidising fruits and vegetables with the tax revenues simultaneously brought about a 5-9 percent decline in the consumption of HFFS and an 11 percent and 7 percent rise in vegetables and fruits consumption, respectively. Weekly per capita greenhouse gas emission could increase by 2 percent when fruits and vegetables are subsidised with the tax revenues rather than decrease by 3 percent when only HFSS food groups are taxed. Taxing HFSS without any subsidy policy in place was more regressive on consumers than when fruits and vegetables are subsidized. In conclusion, imposing a revenue-neutral HFSS tax policy would result in a trade-off between dietary, welfare and environmental goals. The policy scenario adopted by government would depend on the national goal being pursued.

Keywords: Foods high in fats, sugar and salt (HFSS), EASI demand, Scotland, CO_2-eq emission, Revenue-neutral tax

1. Introduction

The consumption of foods high in fat, sugar, and salt (HFSS) is one of the leading causes of non-communicable diseases (NCDs) such as ischaemic heart disease (IHD), stroke, some cancers, and type 2 diabetes (Rayner, 2005). Hypertension, a risk factor for cardiovascular disease, is caused by high intake of salt (Strazzullo, et al., 2009). Similarly, excess sugar intake, a major cause of overweight is a significant risk factor for diabetes and many cancers (Lauby-Secretan et al., 2016; Te Morenga, Mallard and Mann, 2012). High-fat diets are reported to increase oxidative stress in a variety of tissues. According to Hu et al. (2001) coronary heart disease risk can be best reduced by replacing saturated fats with unsaturated fats other than cutting down the total dietary fat.

The high consumption of HFSS has put a strain on economic activities, population health, and living standards of the world population. Statistically, one out of 5 deaths are attributed to the intake of energy-dense foods (Abajobir et al., 2017). In addition, Encarnação et al., (2016) estimated that obesity, one of the major risk factors for non-communicable diseases (NCDs) in Europe accounted for 40% of deaths, which is approximately 17 million deaths in 2012. In Scotland, 65% of adults and 28% of children are living with obesity and related conditions like type 2 diabetes, various cancer types and heart diseases (Butland et al., 2020). In addition, decreased consumption of fruits and vegetables, fibre and oil rich foods among the Scottish population predispose consumers to health problems. Diet is the main contributory factor to 6,697 deaths from coronary heart diseases in 2016, 2,181 deaths from stroke in 2016, 31 per cent of dental decay among children in 2016 and 29 per cent of adult ling with high blood pressure in 2015.

The increasing statistics of ill-health population in the UK (Scotland) and its impact on the country's economy is a major concern for the government and stakeholders. For instance, in 2014/15 the National Health Service (NHS) spent £6.1 billion on treating obesity-related ill health. According to Public Health England, this figure is expected to increase to £9.7 billion per year by the end of 2050 (Holmes, 2021).

The impact of lifestyle choices does not only affect personal health but climate health and goals. According to Hadjikakou (2017) foods high in fat, sugar and salts (discretionary foods) accounts for 33-39 per cent of food-related footprints in Australia. In addition, Hendrie et al. found significantly contribution of discretionary foods to GHGe in the average diet compared to recommended diets in Australia. Although, no empirical estimates have been made for Scotland, it is believed that the figure won't be different from that of Australia. Shifts in dietary patterns can therefore potentially provide benefits for both the environment and health. As a result, the United Nations' sustainable development goals (SDGs) highlight the need for a multifaceted, coordinated effort to limit global temperature rise to 1.5–2 degrees Celsius and prevent the catastrophic effects of climate change (An Action Agenda for Sustainable Development, 2015). This presents opportunities for current food policies to be broadened to include HFSS which contributes to the national agricultural greenhouse gas emission.

Over the years, there's been political interest in adopting fiscal policies as a strategy to reduce the consumption of health damaging and carbon intensive foods. For instance, Ludbrook (2019) suggests that taxes, food campaigns and pledges, and subsidy interventions could be an economic voyage in promoting healthy food consumption across the globe. More importantly, taxes have been described as the most efficient tool that could be used to achieve minimal consumption of HFSS foods such as sugar-sweetened beverages (SSBs), confectionery, cakes, biscuits etc. (Hagenaars et al., 2017). As a result, countries such as USA, Denmark, Mexico, France, South Africa, Hungary, United Kingdom etc has imposed taxes on different kinds of HFSS. Empirical studies assessing the effectiveness of taxes on HFSS to reduce the consumption of SSBs, fat products, and salty confectionaries has been carried out in these countries to highlight the environmental, economic, and health benefits. For instance, In January 2012, France implemented a soda tax, which saw a price increase on drinks with added sugar or sweetener, and a consequent drop in sales. Smed et al. (2016) assessed the effect of the saturated fat tax on food and nutrient intake in Denmark and found a 4 per cent decrease in saturated fat purchase. (Bødker et al., 2015) concluded that total sale of foodstuffs decreased by 0.9 per cent. In Mexico, Barrientos-Gutierrez et al. (2017) found that the sweetened beverage tax resulted in an average BMI reduction of 0.15 kg/m2 per person, which translates into a 2.54% reduction in obesity prevalence.

The impact of HFSS taxes on climate health to the best of our knowledge is under study. Modelling studies by Grout et al., (2022) in New Zealand concluded that taxing junk foods and sugar-sweetened beverage could improve climate health. Scotland has set an ambitious target to achieve a net zero emission on all greenhouse gas (Climate policy, 2019). This means that all avenues to reduce greenhouse gas emissions must be considered to meet the target. To achieve this goal, the study first estimated elasticities for 18 foods and a numeraire consumed in Scotland using an Exact Affine Stone Index (EASI) demand model. The own and cross-price elasticities were used to simulate the effect of a 10 percent increase in the price of HFSS in our data. The changes in quantities were converted into changes in weekly CO_2-equivalent emissions. Two tax policy scenarios were considered: 1) all HFSS were taxed whilst the remaining food groups were untaxed; and 2) all HFSS were taxed, and the revenue generated were used to subsidise fruits and vegetables by 15% consumed in our data.

2. Methods

Data

The data for this study was from KWP which was collected across 3,260 households in Scotland from January to December 2017 and 2018. Household purchase data of 18 food aggregates (which are prices and quantities of purchases) were collected over a 52-week period. The analysis involves only the sample that remained for a minimum of 40 weeks during the data collection period. Per capita weekly averages were used for the estimation. Factors such as household size, were considered during the selection of household samples as well as socio-demographic characteristics like the number of children and adults, age, sex, marital status, and total expenditure per capita.

Eighteen food categories were included in the analysis and a column for all other expenditures. These food categories were sectioned into discretionary and non-discretionary foods. Discretionary foods in the data include take home confectionery, biscuits, take home savouries, cakes pastries and sugar morning goods, total puddings, and desserts, take home sugary drinks, edible ices and ice cream. Dairy products, meat and fish, fats and eggs, fruit, vegetables, grains, prepared ready-to-eat foods, sugar and preserves, condiments and sauces, low-calorie soft drinks and juices, and alcoholic beverages represent the non-discretionary foods, and a single category representing all other food and non-food products. All quantities of the food and food products were weighted/represented in kilograms and prices in pounds to ensure homogeneity or uniformity.

Descriptive statistics

Table 1 shows a list of food categories purchased by the average household and their mean budget shares and mean prices.

The total mean budget share for discretionary foods is 16% while that of non-discretionary foods summed up to 70% with all other expenditures representing 14% of the mean budget share. This seems like consumers in Scotland spent more on healthy foods in 2018 even when their prices are approximately 3 times higher than the discretionary food groups.

In view of this, take-home confectionery had the highest budget share of about 4% among discretionary foods, while total puddings and desserts, and edible ices and ice cream stood at about 1%. Among the non-discretionary foods, sugar and preserves had the lowest budget share of 1% while meat and fish, and all other expenditure had the highest budget share of 14%.

All other expenditures category has the highest mean price of £13.44 with a close range with most of non-discretionary foods while take home sugary drinks has the lowest mean prices of £1.18. This shows that healthy foods are generally more expensive than their counterparts.

Table 1.0 Descriptive statistics (means of budget share, log prices) of each of the food categories.

Food categories	Mean budget shares (%)	Mean prices (£)
Take home confectionery	0.04	3.40
Biscuits	0.03	5.84
Take home savouries	0.02	8.06
Cakes pastries and sugar morning	0.03	1.43
Total puddings and desserts	0.01	5.87
Take home sugary drinks	0.02	1.18
Edible ices and ice cream	0.01	3.72
Dairy products	0.08	3.77
Meat and fish	0.14	8.26
Fats and eggs	0.03	3.12
Fruit	0.06	4.10
Vegetables	0.06	2.65
Grains	0.05	2.91
Prepared ready to eat foods	0.11	5.92
Sugar and preserves	0.01	6.19
Condiments and sauces	0.02	10.61
Low calorie soft drinks and juices	0.05	8.30
Alcoholic beverages	0.09	10.65
All other expenditures	0.14	13.44

Source: Author's own computation based on KWP dataset

Table 2 represents the percentage of Scottish households who did not purchase the food aggregates in the data. Alcoholic beverages seem to be the least consumed foods since it has the highest percentage of about 9.29%. Grains, and all other expenditures represent the most purchased products (0%) which is followed by prepared ready-to-eat foods and low-calorie soft drinks and juices at 2%. This shows that the foods with the least non-consuming percentages are mostly essential foods and nutrients that households use regularly and are also easily assessed. Most of the foods with higher percentages are discretionary foods while non-discretionary foods bear the least percentages.

Table 2.0 The Percentage of non-consuming food households

Food Categories	**Percentage of non-consuming household**
Take home confectionery	0.43%
Biscuits	0.37%
Take home savouries	1.35%
Cakes pastries and sugar morning	0.09%
Total puddings and desserts	2.67%
Take home sugary drinks	2.82%
Edible ices and ice cream	8.47%
Dairy products	0.09%
Meat and fish	0.28%
Fats and eggs	0.15%
Fruit	0.52%
Vegetables	0.09%
Grains	0.00%
Prepared ready to eat foods	0.06%
Sugar and preserves	1.07%
Condiments and sauces	0.15%
Low calorie soft drinks and juices	0.06%
Alcoholic beverages	9.29%
All other expenditures	0.00%

Source: Author's own computation based on KWP dataset

The mean value, standard deviation, and percentages of the socio-demographic components (age, number of children, number of adults, total expenditure per capita, marital status of the household heads, and sex) are represented in Table 3. The mean value depicts the average number of household samples. As shown, age has a mean value of 49.80 and a standard deviation of 12.98. Similarly, number of children in the household sample has a mean of 0.54 while 0.90 is the standard deviation. Number of adults stood at 2.09 mean value with a standard deviation of 2.38. The average total expenditure per capita which demonstrate the average of the total expenditure of households over a 52-week period was 27.96 while the deviation from the sample mean is 15.00. These values will also be adopted in analysing the EASI demand model.

Table 3.0 Mean values and Standard deviations of socio-demographic characteristics of households (%)

Variables	**Mean**	**Standard deviation**
Age	49.80	12.98
Total expenditure per capita	27.96	15.00
Number of children	0.54	0.90
Number of adults	2.09	2.38

Source: Author's own computation based on KWP dataset

CO_2 equivalent emission estimation

The emission estimates for this research study were obtained from the SHARP indicator Database (SHARP-ID). This is to calculate the environmental impact of the observed 18 food categories in Scotland and the methodology was based on the Life Cycle Analysis principle on current production practices (De Valk et al., 2016). The construction of the SHARP ID was based on a total of 182 primary products from four European countries, using various publicly accessible data sources such as Agri-footprint, Europe (BV, 2015); Coinvent, Global Swiss Confederation (Weidema et al., 2013); and primary production reports (Kool, Marinussen, and Blonk, 2012) combined with European production, trade and transport data (Fausto, BACI World Trade Database, and GTAP).

Figure 5 presents the average CO_2-eq estimates for the food groups considered. Among the discretionary food groups, cakes pastries and sugar morning have the highest average CO_2 equivalent emission per kg of food (6.70) with take home sugary drinks emitting the lowest CO_2 equivalent in the category. Overall, meat and fish in the non-discretionary category has the highest level of average CO_2 (16.02) and take-home sugary drinks (0.51) averaging the lowest CO_2 equivalent emission estimate. Clune *et al*., (2016) found similar results when conducting a meta-analysis on red meat. The average estimate shows that dairy products, fats and eggs, and prepared ready-to-eat foods categories are in the medium range of average CO_2 equivalent emissions. Other remaining food categories were found to contribute less than 5 g of CO_2 equivalent emission per kg of food.

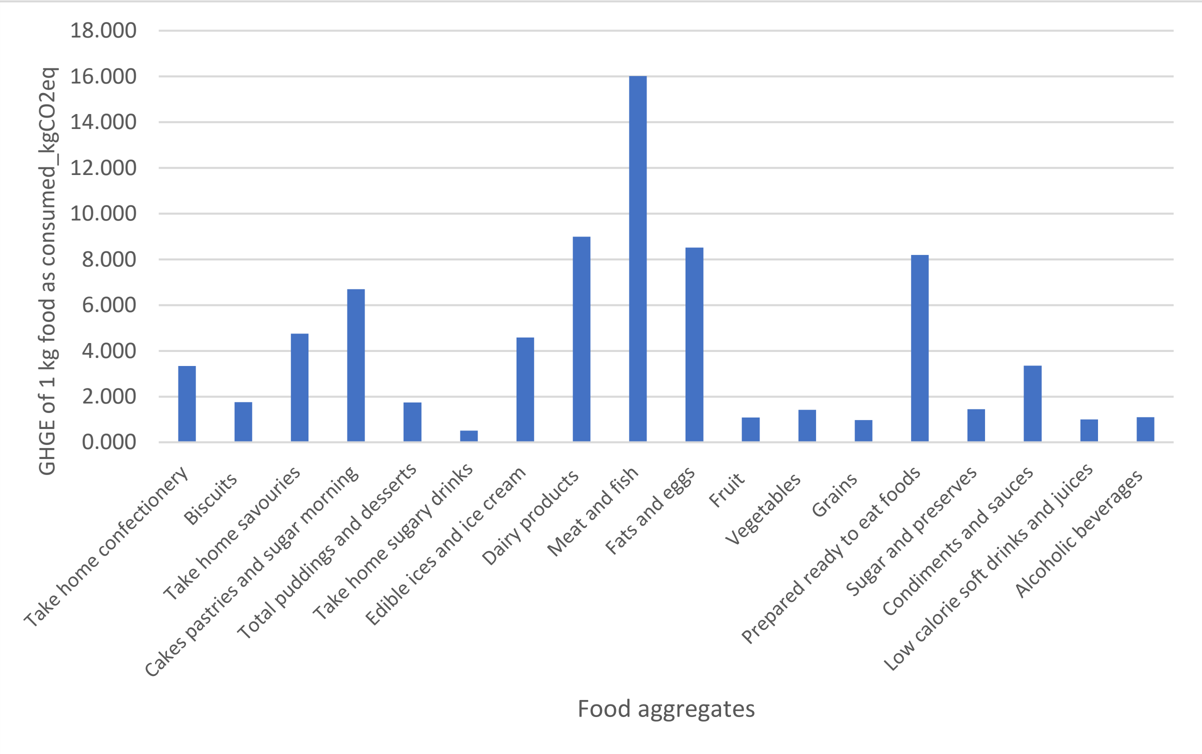

Figure 5.0 Average CO_2-e (kg) per kg of food. Source: Author's own computation

Empirical analysis

The study used the Exact Affine Stone Index (EASI) demand model comprising of real total expenditures, demographic characteristics, and budget shares to estimate price and expenditure elasticities. The own price elasticities and cross-price elasticities were subsequently used to simulate the impact of a value added taxes (VAT) on HFSS on food purchases and greenhouse gas emissions.

EASI demand model

In much verifiable research, the Almost Ideal Demand System (AIDS) and its variants are extensively used because they are utility-based and can have approximate versions estimated through linear regression (Deaton and Muellbauer, 1980). Researchers have demonstrated that the AIDS model has outstanding properties and can estimate the specific preferences of consumers (Lee, Brown and Seale, 1994). There are, however, some limitations to the Almost Ideal Demand System. The Engel curves of the AIDS model, for instance, are linear in real expenditures (Zhen et al., 2013) unlike the EASI demand model which can have any shape over real expenditures (Lewbel and Pendakur, 2009)

There are several advantages to the Exact Affine Stone Index (EASI) demand model, in addition to the fact that it possesses all the superior properties of AIDS. EASI budget share error terms, unlike AIDS model can be interpreted as unobserved heterogeneity or random utility parameters. EASI demand functions can be estimated using nonlinear three-stage least squares (3LS) and Generalised Method of Moments (GMM) (Lars, 1982). Lewbel and Pendakur (2009), concluded that the best demand model for demand analysis is the EASI demand model due to its varied commendable properties.

Literature shows that the linear approximation of the EASI demand model produces similar price elasticities as the full model (Lewbel & Pendakur, 2009).

The linear approximate EASI demand system relates the budget shares w^j, to real food expenditure y^r, demographic characteristics z, and food prices p:

$$w^j \;=\; \sum_{\mathrm{r}}{}^{R} \;=\; {}_0 b_{\mathrm{r}} y^r \;+ Cz \;+ \sum{}^{j}{}_{\mathrm{k=1}} \;\; Ap + \epsilon \qquad (1)$$

where b^r, is a vector of parameters (r= 0,1,2,3,..,5) that control the shape of the Engel curve. y is the real expenditure deflated by the Stone index: $y \;=\; log\,(x) \;-\; (p)w'$ and x is nominal quarterly household weekly per capita expenditure, w represents the vector of mean budget shares. Matrices of parameters to be estimated are A, C, and b_{r}. ϵ is the vector of error terms, which accounts for unobserved preference heterogeneity, this is important when performing welfare analysis. Table 2 shows that non-consuming households in the data range from 0 to 9.5%. Due to the low number of non-consuming households, I used the approach proposed by Zhen et al. (2013) by estimating a Tobit form of the EASI demand model where the latent budget share $W^*{}_{\mathrm{h}}$ is related to observed budget share w^jaccording to $w^j \;\equiv\; max\;(0, w^{j^*})$. The final model was estimated using iterative 3SLS with all the conditions of symmetry, adding up and homogeneity imposed on the demand model. To correct the expenditure endogeneity in our model, Pendakur and Lewbel (2009) proposed instrumenting for the real food expenditure (y) using $\bar{y}$ defined as $\bar{y} = log(x) - log(p)\varpi'$.

Elasticities

Expenditure elasticities, Hicksian and Marshallian price elasticities were derived from (1) following Castellón, Boonsaeng, and Carpio, (2015) and Lewbel and Pendakur (2009). The compensated Hicksian price elasticity of demand for good k with respect to the price of the good *j* was derived by

$$\epsilon = \varpi^{-1}(B) + \Omega\varpi - I \qquad (2)$$

where ϵ is an *n x n* matrix of compensated demand elasticities, ϖ is an identity matrix where the ones have been replaced by the group budget shares, Ω is an *n x n* matrix of ones and I is an identity matrix.

The vector of expenditure elasticities ϑ were subsequently derived by

$$\vartheta = (\varpi)^{-1}(1 + Ap')^{-1}A + 1_{\mathrm{n}} \qquad (3)$$

where $\vartheta$is the *J X 1* vector of estimated expenditure elasticities, A is the expenditure semi-elasticity coefficients which is $\Sigma^{5}{}_{\mathrm{r=0}}A_{\mathrm{r}}y^{r}$, *p* is a vector of mean prices and 1_j is a $J \times 1$ vector of ones.

The matrix of uncompensated Marshallian elasticities, were derived from the Slutsky equation given by $\varepsilon = \epsilon - \varpi\vartheta$

Simulation

The goal of the present study is to estimate the impact of a 10 percent price increase on the purchases of HFSS considering both own and cross price elasticities. The changes in purchases were subsequently used to estimate the effect of the policy on average weekly per capita greenhouse gas emissions. Two policy scenarios were considered: 1) imposing a 10 percent VAT on all HFSS whilst the prices of the remaining food categories were unchanged; and 2) imposing the 10 percent VAT on all HFSS but subsidised the purchases of fruits and vegetables using the revenue generated from HFSS taxes.

Table 4.0 Simulation scenarios Source: Author's own computation

Food groups	CO2-eq Tax on all HFSS	CO2-eq Tax on all HFSS plus subsidy on fruit and vegetables
Take home confectionery	T	T
Biscuits	T	T
Take home savouries	T	T
Cakes pastries and sugar morning	T	T
Total puddings and desserts	T	T
Take home sugary drinks	T	T
Edible ices and ice cream	T	T
Dairy products		
Meat and fish		
Fats and eggs		
Fruit		S
Vegetables		S
Grains		
Prepared ready to eat foods		
Sugar and preserves		
Condiments and sauces		
Low calorie soft drinks and juices		
Alcoholic beverages		

T = 10% VAT; S = Subsidy

3. Results And Discussions

Price and expenditure elasticities

Appendix A presents the own price- and cross-price elasticities of the food categories. All own price elasticities were found to be negative and significant at 5 per cent level. The own price elasticities indicate that increasing the price of the product, holding all other factors constant, would decrease quantity demanded. Three of the 18 food categories were found to be elastic; take home confectionery, take home savouries, and low-calorie soft drinks and juices. This means that a unit change in price for these food products would lead to more than proportionate change in the quantity demanded.

The remaining 15 food categories were found to be inelastic since their absolute values are less than unity. The implication is that fiscal policies aimed at decreasing or increasing consumption needs to be relatively high to achieve an appreciable level of impact. Like our results, Tiffin, Balcombe, Salois and Kehlbacher (2011) also found vegetables and fruits to be inelastic, although fruits were more responsive to price changes than vegetables. This further buttress the need to impose excise taxes on HFSS food groups and use the revenue realised to subsidise healthy food groups like fruits and vegetables.

Cross-price elasticities are off-diagonal estimates which reflect how changes in the price of one food group affects demand in other food groups (Andreyeva, Long and Brownell, 2010).

Relationship between two products can be substitutionary or complementary. In our result, 200 complementarities and 142 substitutions were observed among the food categories. Complimentary commodities are purchased and consumed together while substitutes goods can be replaced easily by other goods with same or similar utility. All compliments have negative cross price elasticities while the positive cross price elasticities are the substitutes. Appendix A shows that cross-price elasticities could be elastic, inelastic, and unit elastic depending on how consumer react to price changes.

For example, total puddings and desserts, take home sugary drinks, vegetables, prepared ready to eat foods, sugar and preserves, and condiments and sauces were found to be substitutes to fruits whilst the rest were complements. This is reasonable because meat and fish are complements to fruit. Also, grains are complements to fruits indicating that consumers buy these categories together. Therefore, an increase in the price of fruit could lead to a reduction in the purchases of grains, meat and fish etc.

All expenditure elasticities were found to be positive and significant at the one per cent level. Expenditure elasticities measure the degree of responsiveness of consumers to expenditure changes. Expenditure elasticities serve as a tool to classify foods or goods as necessity or luxury in demand analysis (Pawlowski and Breuer, 2013). Appendix A shows the expenditure elasticities of all the 18 food categories and a numeraire estimated at the variable means. The study found all the HFSS foods to elastic indicating that they are luxury goods in the consumers' budget. This shows that Scottish households do not consider these foods are vital for their wellbeing. It could also be assumed that households in Scotland consume them on special occasions as observed in Ethiopia by Magrini et al. (2015). All non-discretionary food groups are inelastic in demand except low calorie soft drinks and juices (1.010). The reason could be that most of the foods in the non-discretionary categories are considered as staple foods necessary to keep body and soul together. Therefore, household budgets are perhaps spent on those food groups. However, it's interesting to note that Scottish households consider fruits (0.919), and vegetables (0.935) as necessities in the food basket, although it's almost likened to be unit elastic and as such subsidies on such healthy food groups would encourage healthy diets in Scottish households. These findings are like that of Ecker and Qaim (2008) who found fruits (0.424) and other vegetables (0.432) to be normal goods. Overall, take home sugary drinks (1.221) would react most to food expenditure changes while alcoholic beverages (0.883) are less likely to be responsive to food expenditure changes.

Impact of HFSS excise tax on food purchases

The increasing effect of HFSS consumption has prompted policymakers and researchers to explore policy instruments to encourage healthy diets. This could be achieved by increasing the prices of HFSS foods through excise taxes and applying subsidies on healthy foods. Figure 6 shows the impact of the fiscal policy on the 18 food categories. First, taxes were imposed on all HFSS whilst prices of non-taxed foods remained the same. From the graph, it can be observed that a 10% excise tax on HFSS food groups result in the reduction of HFSS consumption in households in Scotland. HFSS reduced by 6 - 10 percent after taxes; edible ices and ice cream had the lowest reduction whilst total puddings and desserts and take-home sugary drinks had the highest reduction. The policy had unintended effects on non-taxed foods. For instance, the consumption of fruits and vegetables were reduced by 2 and 5 percent respectively. On the other hand, demand for dairy products and grains increased by 2 percent. Reductions in the remaining food groups is between 0 - 5 percent.

However, the second policy scenario shows that taxing HFSS whilst subsidising the prices of fruits and vegetables by the revenue generated led to a significant impact on the consumption of both HFSS and non-discretionary foods. Again, Figure 6 shows a decline in the consumption of HFSS by 5 - 9 percent after subsidies were imposed. A 15 percent subsidy on fruits and vegetables resulted to increase in the quantities demanded by 11 percent and 7 percent, respectively. Although, dairy products, meat and fish, grains, fats and eggs, alcoholic beverages experienced higher demand, there was an insignificant change in the consumption rate of condiments and sauces, and sugar and preserves after imposing HFSS taxes and subsidies.

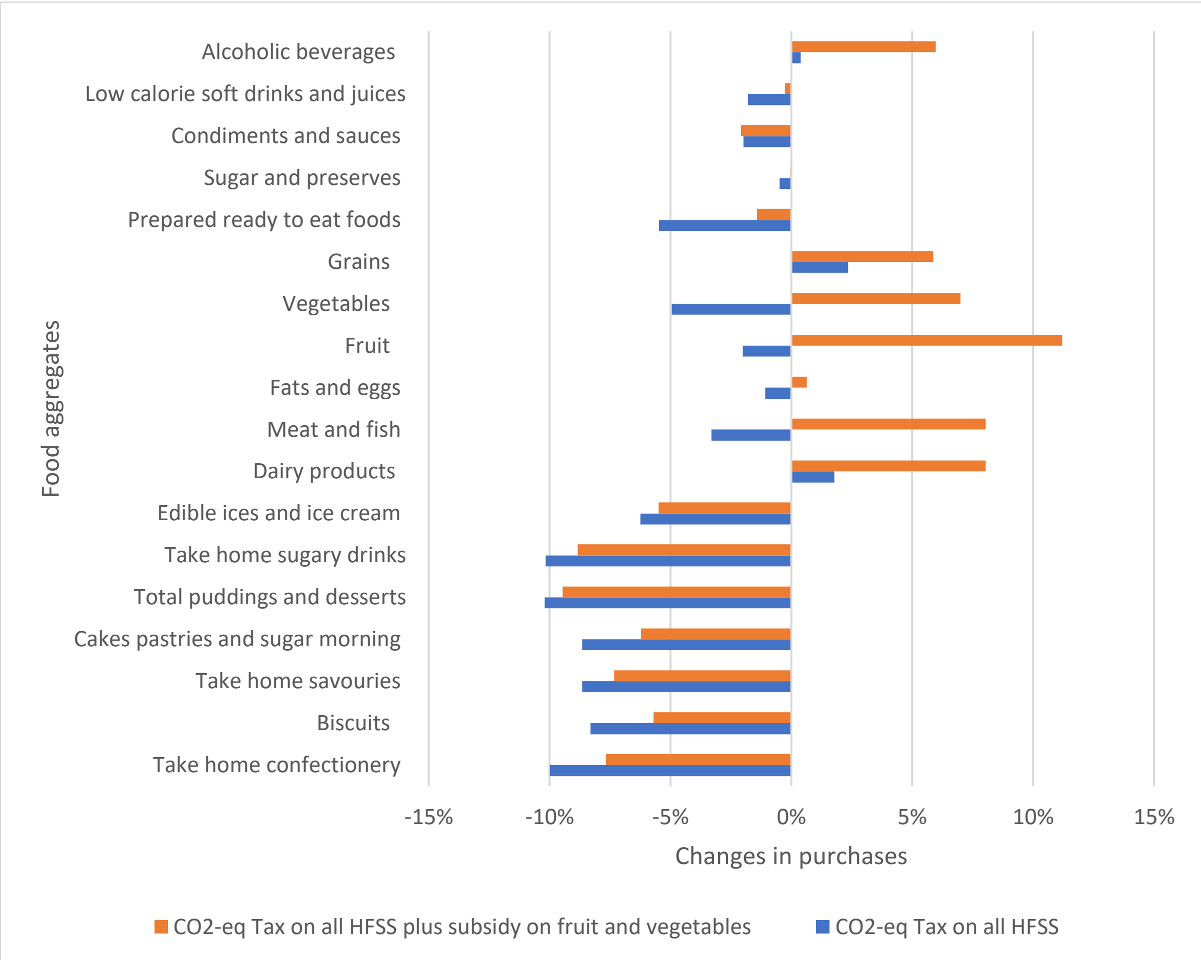

Figure 6.0 Impact of fiscal policy on food purchases. Source: Author's own computation

Impact on CO_2 Equivalent emission (CO_2-Eq) Tax on Food Demand

This section assesses the change in CO_2 equivalent emission after the tax imposition. Figure 7 shows that this study simulated 2 different policy scenarios - the impact of the policy on weekly per capita greenhouse gas emissions when all HFSS are taxed versus when all HFSS are taxed while fruits and vegetables subsidised.

From the analysis, it can be deduced that a food policy where all HFSS food groups are taxed would be more effective in cutting down CO_2 equivalent emission from household food sources. The graph represents the average percentage change in weekly emissions in Scottish households across a 52-week period.

On average, government could reduce emissions by about 3 percent when all HFSS are taxed and the prices of the remaining food categories unchanged. However, government policy that seeks to increase the price of HFSS through taxes while subsidising fruits and vegetables would increase overall weekly per capita emissions by approximately 2 percent. This implies that to achieve a better climate health, there would be a trade-off resulting in less consumption of fruits and vegetables – negative impact on nutrition. It is therefore important for government and stakeholders to consider which of these goals are pressing and pursue their policy goals wisely.

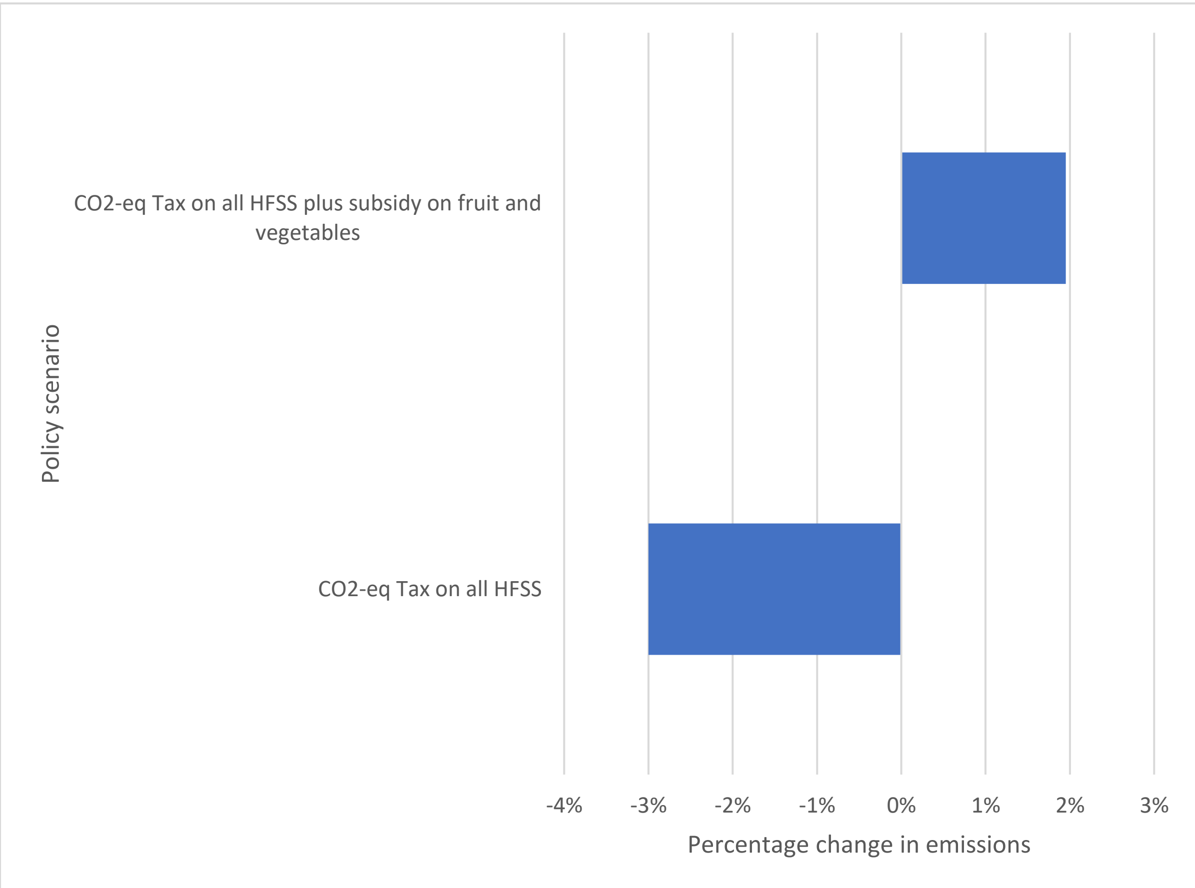

Figure 7.0 Percentage Change in Weekly Emissions. Source: Author's own computation

Impact of CO_2 equivalent Tax on consumer welfare

Taxation of less healthy foods and subsidisation of fruits and vegetables are seen as a multidimensional strategy to improve health outcomes in Scotland and UK at large. However, it is critical to ascertain the impact of such policies on consumer welfare considering the current economic crisis in Scotland due to Covid-19 and Russia-Ukraine invasion.

Figure 8 shows the impact of the policies on consumer welfare. Consumer welfare was estimated using the log of living cost index proposed by Pendakur and Lewbel (2009). The figure shows the increase in expenditure required for the consumer to consume the same basket of goods prior to the implementation of the fiscal policies. When all HFSS are taxed while prices of untaxed foods remain the same, the average consumer would expect about a 16 percent increase in expenditure to meet his/her previous consumption. This means that taxing HFSS impacts the total food expenditure of a household, because a price increase due to taxes does not warrant an increase in the household income. However, when HFSS are taxed whilst fruits and vegetables are subsidised, consumers would require an additional 6 percent increase in expenditure to meet their initial consumption. In summary, consumers are worse off when all HFSS are taxed and there are no subsidies. Implementing both tax policies and subsidizing consumers with the income from such policies is less regressive public policy (Broeks et al. 2020).

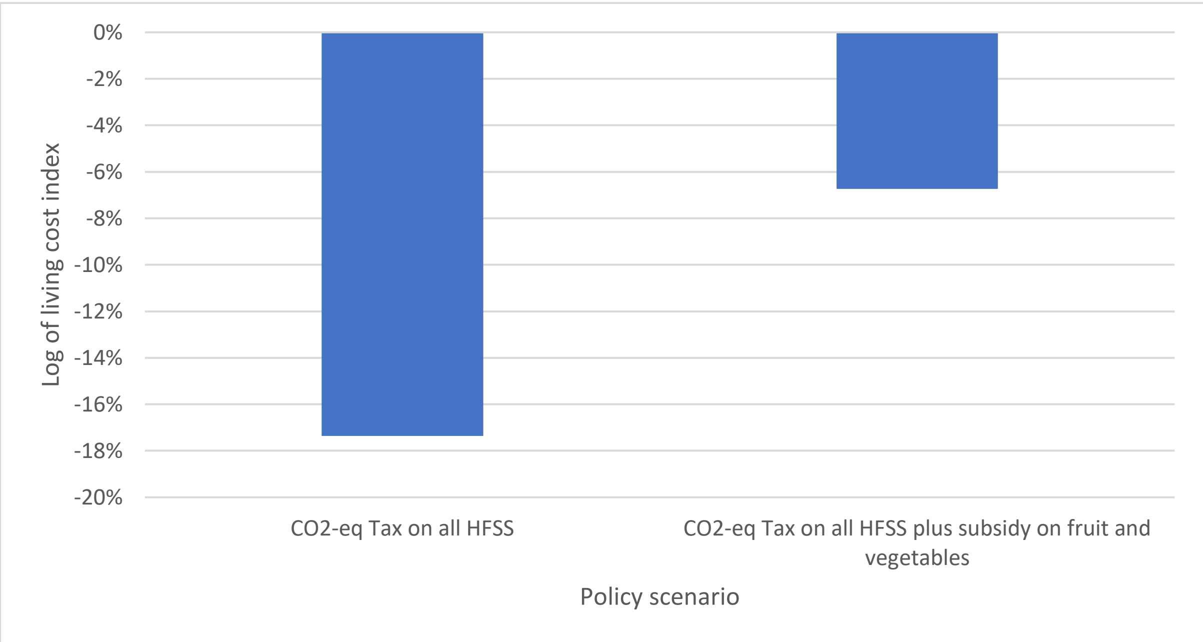

Figure 8.0 Impact of policies on Consumer Welfare
Source: Author's own computation

4. Conclusion

This study aims to estimate the impact of foods high in fats, sugar and salt (HFSS) excise tax on CO2 -equivalent emission and consumer welfare. The paper applied the Exact Affine Stone Index Implicit Marshallian demand system to estimate the demand elasticities for eighteen food categories purchased in Scotalnd.

From the analysis, it is deduced that households in Scotland spend more on healthy foods (80%) than HFSS (16%) even when their prices are higher than HFSS food groups. Among the HFSS, take home confectionery had the highest share of purchases with total puddings and dessert, edible ices and ice cream having the least purchases. For the non-discretionary foods, meat and fish (14%) were the most purchased food groups while sugar and preserves had the lowest budget share indicating the relevance of meat and fish in the consumer's budget.

From the simulation analysis, this study calculated the impact of introducing HFSS excise tax on the 18 food categories while considering two policy scenarios: a 10% tax on HFSS and zero tax on non-discretionary food groups; and a 10% excise tax on HFSS and a revenue-neutral subsidy on fruits and vegetables.

The excise tax (when all HFSS foods were taxed) had an unintended effect on non-taxed foods i.e., the consumption of fruits and vegetables reduced by 2% and 5 %, respectively. Meanwhile, the second policy scenario did not only reduce HFSS consumption in Scottish households by 5-9% but resulted in an 11% and 7% increase in the consumption of fruits and vegetables, respectively.

The impact of the excise tax on greenhouse emission could be positive or negative depending on the policy scenario adopted by government. Taxing HFSS without any subsidy policy in place could reduce CO2-eq emissions by 3%. However, taxing HFSS whilst subsidising fruits and vegetables would result in about 2% increase in CO2-eq emissions.

From the welfare context, consumers would require a 16 percent increase in their food expenditure to meet previous household food consumption, when subsidies are not included in the excise tax policy. However, households would require about 6% (10 per cent less) increase in their initial expenditure when both the excise tax and subsidies are applied. The policy adopted by government would imply a trade-off between environmental, dietary and welfare goals.

Firstly, this research study agrees with some other research studies and recommends that policy makers should consider imposing excise tax alongside subsidies to achieve a better dietary outcome. In view of this imposition, a revenue-neutral tax i.e. allocating funds generated from the HFSS taxes to subsidise healthy foods such as fruits, and vegetables would be the best strategy to ensure sustainability of healthy food consumption. Secondly, the study also recommends that policy makers consider the consumer welfare of fiscal policies on consumers especially those from the lower income groups as the burden of taxes affects the food expenditure most. Finally, the study also recommends that marketing strategies such as sensitisation campaigns, healthy advertisements, and cooking shows are adopted to increase social awareness on the health benefits of sustainable dietary options.

The research study had limitations that should be explored when conducting future research in this area. Firstly, individual taxing of HFSS based on their rates of emissions would be useful for feasible policy reforms to tax products based on their level of emissions and not using a generalised tax across all types of food group, that way specific foods that emits the most greenhouse gas can be identified and work towards reducing their emission. Secondly, the study assumed that the supply chains of HFSS when imposing excise taxes are unaffected. Therefore, future research should explore fiscal policies affect the entire food supply chain and not just consumers. Finally, it is critical that future research is carried out on the impact of greenhouse gas emissions on consumer welfare particularly focused on food security and nutrition.

5. References

1. Andreyeva, T., Long, M. and Brownell, K., 2010. The Impact of Food Prices on Consumption: A Systematic Review of Research on the Price Elasticity of Demand for Food. *American Journal of Public Health*, 100(2), pp.216-222.
2. Bardsley, D., Calder, A. and Currie, E., 2016l. The Scottish Health Survey: Main Report 2016. Vol 1. Edinburgh: The Scottish Government; 2017.
3. Belc, N., Smeu, I., Macri, A., Vallauri, D. and Flynn, K., 2019. Reformulating foods to meet current scientific knowledge about salt, sugar and fats. *Trends in Food Science & Technology*, 84, pp.25-28.
4. Berardi, N., Sevestre, P., Tepaut, M. and Vigneron, A., 2016. The impact of a ‘soda tax’on prices: evidence from French micro data. *Applied Economics*, *48*(41), pp.3976-3994.
5. Brown, A., Esposito, L., Fisher, R., Nicastro, H., Tabor, D. and Walker, J., 2019. Food insecurity and obesity: research gaps, opportunities, and challenges. *Translational Behavioral Medicine*, 9(5), pp.980-987.
6. Broeks, M. J., Biesbroek, S., Over, E. A., van Gils, P. F., Toxopeus, I., Beukers, M. H., & Temme, E. H. (2020). A social cost-benefit analysis of meat taxation and a fruit and vegetables subsidy for a healthy and sustainable food consumption in the Netherlands. *BMC public health*, *20*(1), 1-12.
7. Brown, K., Rumgay, H., Dunlop, C., Ryan, M., Quartly, F., Cox, A., Deas, A., Elliss-Brookes, L., Gavin, A., Hounsome, L., Huws, D., Ormiston-Smith, N., Shelton, J., White, C. and Parkin, D., 2018. The fraction of cancer attributable to modifiable risk factors in England, Wales, Scotland, Northern Ireland, and the United Kingdom in 2015. *British Journal of Cancer*, 118(8), pp.1130-1141.
8. Butland, B., Jebb, S., Thomas, P., Mardell, J. and Parry, V., 2020. *Tackling Obesities: Future Choices*. Government Office for Science. [online] Available at: <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/287937/07-1184x-tackling-obesities-future-choices-report.pdf> [Accessed 3 September 2022].
9. BV, B.A.F., 2015. Agri-footprint 2.0-Part 2: Description of data.
10. Capacci, S., Mazzocchi, M., Shankar, B., Brambila Macias, J., Verbeke, W., Pérez-Cueto, F., Kozioł-Kozakowska, A., Piórecka, B., Niedzwiedzka, B., D'Addesa, D., Saba, A., Turrini, A., Aschemann-Witzel, J., Bech-Larsen, T., Strand, M., Smillie, L., Wills, J. and Traill, W., 2012.
11. Castillo, D., Ramsey, N., Yu, S., Ricks, M., Courville, A. and Sumner, A., 2012. Inconsistent Access to Food and Cardiometabolic Disease: The Effect of Food Insecurity. *Current Cardiovascular Risk Reports*, 6(3), pp.245-250.

12. Climate policy., 2022. *Climate change - gov.scot*. [online] Gov.scot. Available at: <https://www.gov.scot/policies/climate-change/#:~:text=Scotland's%20ambitious%20climate%20change%20legislation,economy%20and%20society%20is%20required.> [Accessed 4 September 2022].
13. Cohen, R., 2017. *Taxes trimmed Mexican soda consumption for two years*. [online] Reuters. Available at: <https://www.reuters.com/article/us-health-soda-taxes-idUKKBN1685JM> [Accessed 6 September 2022].
14. Conrad, D. and Capewell, S., 2012. Associations between deprivation and rates of childhood overweight and obesity in England, 2007–2010: an ecological study. *BMJ Open*, 2(2), p.e000463.
15. Cummins, S., Mckay, L. and Macintyre, S., 2005. McDonald's Restaurants and Neighborhood Deprivation in Scotland and England. *American Journal of Preventive Medicine*, 29(4), pp.308-310.
16. de Valk, E., Hollander, A. and Zijp, M., 2016. Environmental impact of food consumption in the Netherlands.
17. Durand, M.A., Petticrew, M., Goulding, L., Eastmure, E., Knai, C. and Mays, N., 2015. An evaluation of the Public Health Responsibility Deal: informants' experiences and views of the development, implementation and achievements of a pledge-based, public–private partnership to improve population health in England. *Health policy*, *119*(11), pp.1506-1514.
18. Ecker, O., & Qaim, M., 2008. Income and Price Elasticities of Food Demand and Nutrient Consumption in Malawi. *Researchgate*. Retrieved 20 August 2022.
19. Elliott-Green, A., Hyseni, L., Lloyd-Williams, F., Bromley, H. and Capewell, S., 2016. Coverage of sugar-sweetened beverages in the British media: an analysis of public health advocacy versus pro-industry messaging. *The Lancet*, 388, p.S48.
20. Encarnação, R., Lloyd-Williams, F., Bromley, H. and Capewell, S., 2016. Obesity prevention strategies: could food or soda taxes improve health?. *Journal of the Royal College of Physicians of Edinburgh*, *46*(1), pp.32-38.
21. Finkelstein, E., Khavjou, O., Thompson, H., Trogdon, J., Pan, L., Sherry, B. and Dietz, W., 2012. Obesity and Severe Obesity Forecasts Through 2030. *American Journal of Preventive Medicine*, 42(6), pp.563-570.
22. Fitzpatrick M. Junk food. Lancet 2004;363: 1000
23. Fry, J., & Finley, W. (2005). The prevalence and costs of obesity in the EU. *The Proceedings of the Nutrition Society*, *64*(3), 359–362. https://doi.org/10.1079/pns2005443
24. Hadjikakou, M., 2017. Trimming the excess: environmental impacts of discretionary food consumption in Australia. *Ecological Economics*, 131, pp.119-128.
25. Hagenaars, L.L., Jeurissen, P.P.T. and Klazinga, N.S., 2017. The taxation of unhealthy energy-dense foods (EDFs) and sugar-sweetened beverages (SSBs): an overview of patterns observed in the policy content and policy context of 13 case studies. *Health Policy*, *121*(8), pp.887-894.
26. Harris, J., Pomeranz, J., Lobstein, T. and Brownell, K., 2009. A Crisis in the Marketplace: How Food Marketing Contributes to Childhood Obesity and What Can Be Done. *Annual Review of Public Health*, 30(1), pp.211-225.
27. Hendrie, G. A., Baird, D., Ridoutt, B., Hadjikakou, M., & Noakes, M. (2016). Overconsumption of energy and excessive discretionary food intake inflates dietary greenhouse gas emissions in Australia. Nutrients, 8(11), 690.
28. Ho, F.K., Celis-Morales, C.A., Gray, S.R., Katikireddi, S.V., Niedzwiedz, C.L., Hastie, C.E., Lyall, D.M., Ferguson, L.D., Berry, C., Mackay, D., Gill, J.M., Pell, J.P., Sattar, N., & Welsh, P. (2020). Modifiable and non-modifiable risk factors for COVID-19: results from UK Biobank. *medRxiv*.

29. Holmes, J. "Tackling obesity: the role of the NHS in a whole-system approach." *The King's Fund: London, UK* (2021).
30. Hu, F., Manson, J. and Willett, W., 2001. Types of Dietary Fat and Risk of Coronary Heart Disease: A Critical Review. *Journal of the American College of Nutrition*, 20(1), pp.5-19.
31. Jensen, J.D., Smed, S., Aarup, L. and Nielsen, E., 2016. Effects of the Danish saturated fat tax on the demand for meat and dairy products. *Public health nutrition*, *19*(17), pp.3085-3094.
32. Jones, N., Tong, T. and Monsivais, P., 2017. Meeting UK dietary recommendations is associated with higher estimated consumer food costs: an analysis using the National Diet and Nutrition Survey and consumer expenditure data, 2008–2012. *Public Health Nutrition*, 21(5), pp.948-956.
33. Jones, N., Tong, T. and Monsivais, P., 2017. Meeting UK dietary recommendations is associated with higher estimated consumer food costs: an analysis using the National Diet and Nutrition Survey and consumer expenditure data, 2008–2012. *Public Health Nutrition*, 21(5), pp.948-956.
34. Knai, C., Petticrew, M., Durand, M.A., Eastmure, E., James, L., Mehrotra, A., Scott, C. and Mays, N., 2015. Has a public–private partnership resulted in action on healthier diets in England? An analysis of the Public Health Responsibility Deal food pledges. *Food policy*, *54*, pp.1-10.
35. Larson, N., Story, M. and Nelson, M., 2009. Neighborhood Environments. *American Journal of Preventive Medicine*, 36(1), pp.74-81.e10.
36. Lauby-Secretan, B., Scoccianti, C., Loomis, D., Grosse, Y., Bianchini, F. and Straif, K., 2016. *Body Fatness and Cancer -Viewpoint of the IARC Working Group*. England: The new England Journal of Medicine.
37. Lim, S.S., Vos, T., Flaxman, A.D., Danaei, G., Shibuya, K., Adair-Rohani, H., AlMazroa, M.A., Amann, M., Anderson, H.R., Andrews, K.G. and Aryee, M., 2012. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The lancet*, *380*(9859), pp.2224-2260.
38. Lopez, R., Agullo, P. and Lakshmanaswamy, R., 2013. Links between obesity, diabetes and ethnic disparities in breast cancer among Hispanic populations. *Obesity Reviews*, 14(8), pp.679-691.
39. Magrini, E., Morales-Opazo, C., Jean Balié., 2015. Price Shocks, Volatility and Household Welfare: A Cross-Country Inquiry, Working Paper 11, ULYSSES project, EU 7th Framework Programme, Project 312182 KBBE.2012.1.4-05, http://www.fp7-ulysses.eu/ , 51 pp.
40. Martin, L., Bauld, L. and Angus, K., 2017. Rapid evidence review: The impact of promotions on high fat, sugar, and salt (HFSS) food and drink on consumer purchasing and consumption behaviour and the effectiveness of retail environment interventions. Edinburgh: NHS Health Scotland; 2017.
41. Mason, 2015. *Lipton Ice Tea reduces sugar and updates range*. [online] morningadvertiser.co.uk. Available at: <https://www.morningadvertiser.co.uk/Article/2015/04/17/Lipton-Ice-Tea-reduces-sugar-and-updates-range> [Accessed 5 September 2022].
42. Meyerhoefer, C., Ranney, C. and Sahn, D., 2005. Consistent Estimation of Censored Demand Systems Using Panel Data. *American Journal of Agricultural Economics*, 87(3), pp.660-672.
43. Mombarg, H. and Kool, A., 2004. *Cultivation with future energy and climate yardstick: final report* (No. OV0407). Plant Research International.

44. Mombarg, H. and Kool, A., 2004. *Telen met toekomst energie-en klimaatmeetlat: eindrapport* (No. OV0407). Plant Research International.
45. Morris, M., Hulme, C., Clarke, G., Edwards, K. and Cade, J., 2014. What is the cost of a healthy diet? Using diet data from the UK Women's Cohort Study. *Journal of Epidemiology and Community Health*, 68(11), pp.1043-1049.
46. Mozaffarian, D. and Capewell, S., 2011. United Nations' dietary policies to prevent cardiovascular disease. *Bmj*, *343*.
47. Mytton, O., Gray, A., Rayner, M. and Rutter, H., 2007. Could targeted food taxes improve health?. *Journal of Epidemiology & Community Health*, *61*(8), pp.689-694.
48. nhs.uk. 2019. *High blood pressure (hypertension) - Causes*. [online] Available at: <https://www.nhs.uk/conditions/high-blood-pressure-hypertension/causes/> [Accessed 19 July 2022].
49. Nnoaham, K.E., 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*(5), pp.1324-1333.
50. NPD Group, Inc, 2015. *An overview of the out of home market in Scotland*.
51. OpenSAFELY Collaborative, Williamson E, Walker AJet al. (2020)OpenSAFELY: factors associated with COVID-19- related hospitaldeath in the linked electronic health records of 17 million adultNHS patients. medRxiv 2020. [Epub ahead of print].
52. PAWLOWSKI, T. and BREUER, C., 2013. [online] Tim-pawlowski.de. Available at: <https://tim-pawlowski.de/wp-content/uploads/2013/05/Pawlowski-T.-Breuer-C.-2012.pdf> [Accessed 19 August 2022].
53. Ploeg, M.V., Breneman, V.E., Farrigan, T.L., Hamrick, K.S., Hopkins, D., Kaufman, P.R., Lin, B.H., Nord, M., Smith, T.A., Williams, R.B., Kinnison, K.E., Olander, C., Singh, A., & Tuckermanty, E. (2012). Access to Affordable and Nutritious Food-Measuring and Understanding Food Deserts and Their Consequences: Report to Congress.
54. Policies to promote healthy eating in Europe: a structured review of policies and their effectiveness. *Nutrition Reviews*, 70(3), pp.188-200.
55. Powell, P., Spears, K., and Rebori, M. *2010*, What is Obesogenic Environment?, Extension | University of Nevada, Reno, FS-10-11
Rayner, M. and Scarborough, P., 2005. The burden of food related ill health in the UK. Journal of Epidemiology & Community Health, 59(12), pp.1054-1057.
56. Programme, N., 2014. *National Child Measurement Programme - England, 2013-14 - NHS Digital*. [online] NHS Digital. Available at: <https://digital.nhs.uk/data-and-information/publications/statistical/national-child-measurement-programme/2013-14-school-year> [Accessed 29 August 2022].
57. Public Health England. *From evidence into action: opportunities to protect and improve the nation's health*. October 2014. https://www. gov. uk/government/publications/from-evidence-into-action- opportunities-to-protect-and-improve-the-nations-health (accessed 25/11/15).
Swinburn, B., Eggar, G., & Raza., F. (1999). Dissecting obesogenic environments; the development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Preventive Medicine*, 29(6), 563-570.
58. Romo, R., 2011. *Mexico's other enemy: Obesity rates triple in last 3 decades*. [online] Edition.cnn.com. Available at: <http://edition.cnn.com/2011/WORLD/americas/01/04/mexico.obesity/index.html> [Accessed 4 September 2022].

59. Scottish health survey, 2017. *Scottish Health Survey 2017: supplementary tables*. [online] Gov.scot. Available at: <https://www.gov.scot/publications/scottish-health-survey-2017-supplementary-tables/> [Accessed 5 September 2022].
60. Simonnet, A., Chetboun, M., Poissy, J., Raverdy, V., Noulette, J., Duhamel, A., Labreuche, J., Mathieu, D., Pattou, F., Jourdain, M., & LICORN and the Lille COVID-19 and Obesity study group (2020). High Prevalence of Obesity in Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) Requiring Invasive Mechanical Ventilation. *Obesity (Silver Spring, Md.)*, *28*(7), 1195–1199. https://doi.org/10.1002/oby.22831
61. Strazzullo, P., D'Elia, L., Kandala, N. and Cappuccio, F., 2009. Salt intake, stroke, and cardiovascular disease: meta-analysis of prospective studies. *BMJ*, 339(nov24 1), pp.b4567-b4567.
62. Swinburn, B., Sacks, G., Hall, K., McPherson, K., Finegood, D., Moodie, M. and Gortmaker, S., 2011. The global obesity pandemic: shaped by global drivers and local environments. *The Lancet*, 378(9793), pp.804-814.
63. Swinburn, B.A., Sacks, G., Hall, K.D., McPherson, K., Finegood, D.T., Moodie, M.L. and Gortmaker, S.L., 2011. The global obesity pandemic: shaped by global drivers and local environments. *The Lancet*, *378*(9793), pp.804-814.
64. Te Morenga, L., Mallard, S. and Mann, J., 2012. Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. *BMJ*, 346(jan15 3), pp.e7492-e7492.
65. The Food & Drink Federation. 2012. *Reformulation guide*. [online] Available at: <https://www.fdf.org.uk/fdf/resources/publications/guidance/reformulation-guide/> [Accessed 18 July 2022].
66. The Scottish Public Health Obeservatory, 2017. *Obesity and health inequalities in Scotland*. Edinburgh.
67. Thompson, C., Clarke, G., Clarke, M. and Stillwell, J., 2012. Modelling the future opportunities for deep discount food retailing in the UK. *The International Review of Retail, Distribution and Consumer Research*, 22(2), pp.143-170.
68. Tiffin, R., Balcombe, K., Salois, M. and Kehlbacher, A., 2011. *Estimating Food and Drink Elasticities*. [online] England: The University of Reading. Available at: <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/137726/defra-stats-foodfarm-food-price-elasticities-120208.pdf> [Accessed 21 August 2022].
69. UK Parliament. Childhood obesity inquiry – publications. Health Select Committee Inquiry into Childhood Obesity 2015. http://www.parliament.uk/business/committees/committees-a-z/commons-select/health-committee/inquiries/parliament-2015/inquiry/publications (accessed 25/11/15)
70. Wang, Y., Beydoun, M., Liang, L., Caballero, B. and Kumanyika, S., 2008. Will All Americans Become Overweight or Obese? Estimating the Progression and Cost of the US Obesity Epidemic. *Obesity*, 16(10), pp.2323-2330.
71. Weidema, B.P., Bauer, C., Hischier, R., Mutel, C., Nemecek, T., Reinhard, J., Vadenbo, C.O. and Wernet, G., 2013. Overview and methodology: Data quality guideline for the ecoinvent database version 3.
72. WHO (World Health Organization) (2020). *Obesity and overweight*. [online] Available at: <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight> [Accessed 3 September 2022].
73. Wilde, P., 2000. Deaton, Angus. The Analysis of Household Surveys: A Microeconometric Approach to Development Policy. Baltimore MD: Johns Hopkins

University Press (Published for the World Bank), 1996, 479 pp., $@@-@@39.95. *American Journal of Agricultural Economics*, 82(3), pp.780-782.

Appendix A – Price and Expenditure elasticities

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Take home confectionery (1)	**-1.022**	-0.024	-0.064	0.031	0.056	-0.004	0.028	0.006	-0.023	0.008
	(0.018)	(0.016)	(0.018)	(0.014)	(0.025)	(0.024)	(0.031)	(0.009)	(0.009)	(0.013)
Biscuits (2)	-0.021	**-0.792**	0.071	0.062	-0.101	0.005	-0.055	0.006	0.008	-0.020
	(0.011)	(0.041)	(0.035)	(0.02)	(0.042)	(0.026)	(0.052)	(0.01)	(0.009)	(0.018)
Take home savouries (3)	-0.042	0.062	**-1.081**	0.030	0.088	-0.022	0.100	0.047	-0.015	0.014
	(0.011)	(0.03)	(0.051)	(0.02)	(0.043)	(0.027)	(0.054)	(0.01)	(0.009)	(0.018)
Cakes pastries and sugar morning (4)	0.022	0.074	0.042	**-0.984**	-0.039	-0.003	0.023	0.001	-0.014	-0.021
	(0.011)	(0.023)	(0.027)	(0.025)	(0.035)	(0.026)	(0.044)	(0.01)	(0.009)	(0.016)
Total puddings and desserts (5)	0.014	-0.042	0.042	-0.015	**-0.987**	0.026	-0.058	-0.011	0.023	-0.014
	(0.007)	(0.017)	(0.02)	(0.012)	(0.036)	(0.017)	(0.032)	(0.006)	(0.006)	(0.011)
Take home sugary drinks (6)	-0.003	0.007	-0.017	-0.001	0.050	**-0.979**	-0.073	0.046	-0.017	0.027
	(0.013)	(0.02)	(0.024)	(0.017)	(0.032)	(0.038)	(0.04)	(0.01)	(0.009)	(0.016)
Edible ices and ice cream (7)	0.007	-0.020	0.046	0.008	-0.053	-0.036	**-0.577**	-0.006	-0.007	-0.024
	(0.008)	(0.02)	(0.024)	(0.015)	(0.03)	(0.02)	(0.052)	(0.007)	(0.007)	(0.013)
Dairy products (8)	-0.006	0.013	0.156	-0.008	-0.080	0.164	-0.061	**-0.963**	0.034	0.022
	(0.019)	(0.029)	(0.034)	(0.025)	(0.046)	(0.04)	(0.058)	(0.021)	(0.014)	(0.023)
Meat and fish (9)	-0.119	0.025	-0.108	-0.089	0.262	-0.159	-0.142	0.052	**-0.745**	-0.091
	(0.03)	(0.047)	(0.054)	(0.04)	(0.073)	(0.063)	(0.092)	(0.024)	(0.031)	(0.036)
Fats and eggs (10)	-0.002	-0.023	0.014	-0.023	-0.035	0.030	-0.069	0.006	-0.017	**-0.789**
	(0.009)	(0.018)	(0.021)	(0.014)	(0.027)	(0.021)	(0.034)	(0.008)	(0.007)	(0.018)
Fruit (11)	-0.030	-0.039	-0.046	-0.073	0.051	0.027	-0.091	-0.092	-0.023	-0.044
	(0.021)	(0.028)	(0.033)	(0.025)	(0.045)	(0.041)	(0.056)	(0.016)	(0.015)	(0.023)
Vegetables (12)	-0.037	-0.154	0.007	-0.056	-0.120	-0.114	-0.021	-0.024	-0.102	-0.004
	(0.017)	(0.03)	(0.035)	(0.025)	(0.047)	(0.037)	(0.058)	(0.014)	(0.013)	(0.022)
Grains (13)	-0.002	0.010	0.151	0.044	-0.023	0.096	-0.041	-0.055	-0.057	-0.017
	(0.013)	(0.029)	(0.034)	(0.021)	(0.043)	(0.03)	(0.054)	(0.011)	(0.01)	(0.019)
Prepared ready to eat foods (14)	-0.059	-0.082	-0.137	-0.007	-0.002	-0.093	-0.168	-0.076	0.087	-0.046
	(0.029)	(0.049)	(0.057)	(0.041)	(0.077)	(0.063)	(0.096)	(0.024)	(0.022)	(0.038)
Sugar and preserves (15)	0.007	-0.028	0.009	-0.011	-0.027	0.023	-0.022	0.007	-0.015	0.032
	(0.006)	(0.014)	(0.016)	(0.01)	(0.021)	(0.015)	(0.026)	(0.006)	(0.005)	(0.009)
Condiments and sauces (16)	-0.025	-0.043	-0.076	-0.008	0.001	-0.036	-0.011	0.041	0.010	0.043
	(0.007)	(0.015)	(0.018)	(0.012)	(0.023)	(0.017)	(0.029)	(0.006)	(0.006)	(0.011)
Low calorie soft drinks and juices (17)	-0.063	0.028	-0.074	-0.003	-0.018	-0.059	0.009	0.051	-0.007	0.036
	(0.012)	(0.014)	(0.016)	(0.013)	(0.022)	(0.022)	(0.028)	(0.008)	(0.008)	(0.012)
Alcoholic beverages (18)	0.069	-0.024	0.016	-0.001	-0.023	-0.033	0.035	-0.006	-0.011	0.019
	(0.021)	(0.02)	(0.022)	(0.019)	(0.031)	(0.033)	(0.039)	(0.013)	(0.012)	(0.017)
others (19)	0.096	0.001	-0.003	-0.017	-0.022	-0.034	0.030	-0.027	-0.050	-0.084
	(0.02)	(0.023)	(0.023)	(0.021)	(0.014)	(0.021)	(0.017)	(0.032)	(0.054)	(0.017)

Appendix A – Price and Expenditure elasticities cont'd

	11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**Expenditure**
Take home confectionery (1)	-0.008	-0.014	0.008	-0.011	0.030	-0.040	-0.045	0.044	0.032	1.218
	(0.014)	(0.011)	(0.01)	(0.01)	(0.018)	(0.016)	(0.01)	(0.009)	(0.02)	0.025
Biscuits (2)	-0.014	-0.067	0.008	-0.017	-0.050	-0.057	0.017	-0.002	-0.001	1.049
	(0.012)	(0.014)	(0.016)	(0.012)	(0.026)	(0.022)	(0.008)	(0.006)	(0.023)	0.023
Take home savouries (3)	-0.015	0.004	0.076	-0.026	0.016	-0.092	-0.036	0.009	-0.002	1.060
	(0.013)	(0.014)	(0.017)	(0.012)	(0.026)	(0.022)	(0.008)	(0.006)	(0.023)	0.026
Cakes pastries and sugar morning (4)	-0.032	-0.025	0.033	0.003	-0.019	-0.006	0.001	0.007	-0.003	1.121
	(0.013)	(0.013)	(0.014)	(0.011)	(0.023)	(0.02)	(0.008)	(0.007)	(0.021)	0.022
Total puddings and desserts (5)	0.010	-0.022	-0.005	0.000	-0.021	0.002	-0.004	-0.001	-0.003	1.023
	(0.008)	(0.009)	(0.01)	(0.007)	(0.016)	(0.014)	(0.005)	(0.004)	(0.014)	0.036
Take home sugary drinks (6)	0.015	-0.035	0.046	-0.012	0.037	-0.034	-0.022	0.000	-0.003	1.221
	(0.014)	(0.013)	(0.013)	(0.011)	(0.022)	(0.019)	(0.01)	(0.007)	(0.021)	0.038
Edible ices and ice cream (7)	-0.013	-0.002	-0.007	-0.013	-0.014	-0.004	0.004	0.007	0.002	1.164
	(0.01)	(0.01)	(0.012)	(0.009)	(0.019)	(0.016)	(0.006)	(0.004)	(0.017)	0.045
Dairy products (8)	-0.115	-0.028	-0.090	-0.052	0.044	0.185	0.086	0.004	-0.023	0.998
	(0.021)	(0.019)	(0.019)	(0.017)	(0.032)	(0.028)	(0.014)	(0.012)	(0.032)	0.016
Meat and fish (9)	-0.050	-0.236	-0.166	0.103	-0.160	0.075	-0.032	-0.007	-0.068	0.967
	(0.034)	(0.03)	(0.03)	(0.028)	(0.05)	(0.044)	(0.023)	(0.019)	(0.054)	0.015
Fats and eggs (10)	-0.019	-0.002	-0.010	-0.012	0.063	0.064	0.019	0.008	-0.021	0.947
	(0.01)	(0.01)	(0.011)	(0.009)	(0.018)	(0.016)	(0.007)	(0.005)	(0.017)	0.020
Fruit (11)	**-0.714**	0.050	-0.047	0.029	0.066	0.026	-0.006	-0.034	-0.016	0.919
	(0.032)	(0.02)	(0.019)	(0.018)	(0.031)	(0.028)	(0.016)	(0.015)	(0.034)	0.026
Vegetables (12)	0.050	**-0.635**	-0.044	0.023	0.013	0.204	0.065	-0.006	-0.033	0.935
	(0.019)	(0.025)	(0.019)	(0.016)	(0.031)	(0.027)	(0.013)	(0.011)	(0.031)	0.019
Grains (13)	-0.036	-0.035	**-0.754**	0.010	0.009	0.042	-0.001	-0.007	-0.017	0.948
	(0.015)	(0.015)	(0.024)	(0.013)	(0.028)	(0.023)	(0.009)	(0.007)	(0.025)	0.016
Prepared ready to eat foods (14)	0.060	0.046	0.026	**-0.822**	-0.192	-0.322	-0.079	-0.018	-0.048	0.974
	(0.033)	(0.031)	(0.031)	(0.038)	(0.052)	(0.045)	(0.022)	(0.018)	(0.055)	0.017
Sugar and preserves (15)	0.015	0.002	0.002	-0.024	**-0.872**	0.027	0.027	0.006	-0.008	0.939
	(0.007)	(0.007)	(0.008)	(0.006)	(0.019)	(0.012)	(0.005)	(0.004)	(0.012)	0.026
Condiments and sauces (16)	0.007	0.062	0.015	-0.055	0.035	**-0.973**	0.006	0.002	-0.007	0.889
	(0.009)	(0.009)	(0.009)	(0.007)	(0.015)	(0.018)	(0.006)	(0.004)	(0.014)	0.023
Low calorie soft drinks and juices (17)	-0.001	0.054	0.002	-0.031	0.092	0.019	**-1.056**	0.019	0.003	1.010
	(0.013)	(0.01)	(0.009)	(0.009)	(0.016)	(0.014)	(0.013)	(0.009)	(0.018)	0.021
Alcoholic beverages (18)	-0.055	-0.016	-0.020	-0.023	0.028	0.006	0.024	**-0.904**	-0.020	0.883
	(0.022)	(0.016)	(0.014)	(0.014)	(0.023)	(0.02)	(0.017)	(0.036)	(0.035)	0.039
Others (19)	-0.011	-0.055	-0.030	-0.042	-0.049	-0.020	0.022	-0.001	**-0.861**	1.085
	(0.034)	(0.031)	(0.025)	(0.055)	(0.012)	(0.014)	(0.018)	(0.035)	(0.683)	0.040