Internalizing the Public Cost of Obesity in Spain: Distributional Effects on Nutrient Intake

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The authors have nothing to disclose.

Abstract

Studies dealing with obesity have confronted it either from the fiscal policy or from economic cost perspective. There is the need to target fiscal policy goals at the economic cost that obesity imposes on society instead of simulating arbitrary taxes schemes. This paper analyzes the effectiveness of imposing a revenue-neutral fat tax in Spain addressed to internalize the public health expenditure associated to obesity. Results suggest that this tax policy led to an improvement in the diet quality, and decreased the consumption of saturated fatty acid, sodium, and cholesterol. From the welfare perspective, the tax is regressive across all household segments.

Keywords: Revenue-neutral fat tax, Spain, Demand Analysis, Obesity

1. Introduction

After the UK, Spain has the highest prevalence rate of obesity in the EU (OECD, 2012). The prevalence of overweight and obesity among Spanish adults was 53.7% in 2012 (ENIDE, 2012). About 44% of diabetes, 23% of ischemic heart disease and 7–41% of certain cancer burdens are due to overweight and obesity (WHO, 2009). Consequently, government spends a large amount of the national budget on public health care to maintain a higher quality of life among the populace

(Thiele and Roosen, 2018). In Spain, obesity accounts for 7% (5 billion Euros) of the total government expenditure in the health sector (Vázquez and López, 2002).

The relationship between dietary fat content and obesity has received increasing attention among researchers and policy makers (Lin et al., 2014). Drewnowski (2007) blames the rising obesity rates on two main nutrients: dietary fats and added sugars. As a result, some countries in Europe have implemented nutrient taxes with the objective of reducing the prevalence of obesity. Taxes targeted at added sugars have been imposed in the following countries: Hungary, in 2011(Escobar et al., 2013); Finland, in 2011 and France, in 2012 (Berardi et al., 2016). Denmark was the first country to introduce a tax on saturated fat in October 2011 (Jensen et al., 2016; Smed, 2012) but abolished it in 2012.

Two strands of research therefore prevail: 1) studies targeted at estimating the effectiveness of arbitrary tax reforms to reduce obesity (Jensen and Smed, 2013; Sarlio-Lähteenkorva and Winkler, 2015). However, the impact is more regressive on low-income households as they tend to derive most of their calories from fat/sugar based foods. 2) Studies that quantify the direct and indirect cost of obesity to society (Finkelstein et al., 2003; Thorpe et al., 2004; Withrow and Alter, 2011). Even though these two strands of studies are targeted at obesity, no study has linked the two perspectives.

In this paper, we have deviated from studies that simulate arbitrary tax rates to reduce consumption of unhealthy foods or calculate the public cost of obesity. Rather, we have proposed a link between these two strands of studies by showing that a revenue neutral tax reform (based on fat composition of foods) can allow government to effectively internalize the 7%[1] of total annual health expenditure (Krief, n.d.; cf. Mora et al., 2015; Vázquez and López, 2002) that obesity imposes on annual government budget. Specifically, our goal is to assess the effectiveness of internalizing the social cost of obesity on diet quality and welfare. The impact of the fiscal policy on food consumption may have important distributional and nutritional consequences; however, the effect is different across different policy scenarios and geographical context. A revenue-neutral tax i.e. taxing unhealthy foods whilst subsidizing healthy ones, can minimize the extent to which different socio-demographic groups are affected and the extent of variation in the daily caloric requirement. We aim at contributing to the existing literature in: 1) estimating the marginal damage cost of obesity from the direct and indirect cost of obesity in Spain; 2) simulating the effect of a revenue-neutral tax scenario that internalizes the estimated direct and indirect cost of obesity to the government; and 3) assessing the welfare and nutritional effects of the tax reform for household groups that are highly associated with obesity.

Contrary to studies that used the Almost Ideal Demand System (AIDS) model (Escario and Molina, 2004) or the Linear Expenditure System (LES) (Leung et al., 1999) to model tax reforms, this study relied on an Exact Affine Stone Index (EASI) demand system (Lewbel and Pendakur, 2009) to simulate the global effects of the fiscal policy reform on nutritional quality and consumer welfare, as well as among some sociodemographic segments, based on homescan data from Catalonia. Body Mass Index (BMI) – kg/m^2 of the household head and the presence of kids within the household were used as segmentation variables.

[1] This estimate has not been updated, studies by OECD suggest that government's expenditure on health as a percentage of GDP only increased by 22% between 2000 and 2016. Similarly, the rate of obesity between 2000 and 2015 increased by 20% (OECD, 2017, 2011).. Since the changes in these estimates are correlate, our use of prior estimate of 7% is justified.

The remainder of this paper is organized as follows: the next section provides a description of methods i.e. data and an empirical methodology. In the third section, results and discussions of the analysis are presented, and finally the work is concluded with recommendations and limitations.

2. Methods

Data

We have used day-to-day household food purchase data from the 2012 Kantar Home scan panel, collated by the Kantar Worldpanel for the region of Catalonia. Each household that participated in the data collection process was given a scanner to scan the Universal Product Code (UPC) information of all products bought from retailers. Households also recorded, in a book, non-UPC items such as fresh fruits or vegetables, and in-store packaged breads and meats. The information retrieved from consumers includes purchase store type, price and weight of the product, unit of measurement (i.e. grams, liters or units), product-specific details (such as container type, barcode, and flavor) and household socioeconomic characteristics such as social class, presence of children, and body mass index. Using the product-specific barcodes as the basic unit of aggregation, quantities and expenditures for each food product were aggregated to the annual[2] level for each household. From the panel of 1,146 households, a static panel of households that had remained in the sample for at least 42 weeks were considered for our analysis (655 households). Fifteen food aggregates based on Spanish nutritional guidelines we considered for our empirical estimation (see Table 1). While using home scan data is an important novelty of our paper, we acknowledge that the time period when the data was taken and the tax simulation exercise differ. However, this does not affect our results greatly because data from the Spanish Ministry of Agriculture indicate that

[2] We have aggregated our static panel to cross-sectional data because of the difficulty of disentangling seasonal effects that span the one year under consideration and to mitigate the problem of zero purchases, which could not be handled with the double hurdle demand model due to convergence issues as we are dealing with a large number of food categories.

per capita consumption has been relatively stable between the period 2012 and 2017 decreasing by only 4.01%.

For ease of estimation, all prices and quantities were converted into Euros and kilograms. To move from the annual panel to cross-sectional data, prices for each respondent were aggregated using barcodes as the basic unit of aggregation (see Zhen et al., 2014). To deal with the limitations of unit values from aggregating our price data, we followed Diewert (1998) to construct Fisher price indices[3] for each of the 15 food groups using their product barcodes. In this case, the Fisher price index is the deviation of the price paid by a household relative to the average household in the year. This was a three-step procedure. To illustrate the procedure, let us consider the fish and sea food category.

1) In the first stage, since each product is uniquely identified by a particular barcode, we calculated the unit value U_{gji} for all food items with the same barcode under each sub-category *g* within aggregate food group *j* for household *i* using:

$$\boldsymbol{U_{gji}} = \frac{\sum_{v=1}^{V} p_{mgj}^{i} * q_{mgj}^{i}}{\sum_{v=1}^{V} q_{mgj}^{i}} \qquad (1)$$

where p_{mgj}^{i} represents the price of food with barcode *m* paid for by individual *i* for sub-category product *g* within the food group *j* and $q_{mgj}^{i}$is the quantity of product with barcode *m* paid for by individual *i* for sub-category product *g* within aggregate food group *j*.

2) In the second stage, unit values obtained from (1) (U_{gji}) were used to calculate the Laspeyeres and Paache price indices for each food group *j* using the following expressions:

[3] Implementing the Fisher price index allows us to reduce the level of heterogeneity bias in the aggregation of our data in cross-sectional data and abstract out quality variation based on product heterogeneity (Silver and Heravi, 2006; Zhen et al., 2014).

$$\boldsymbol{P_j^i} = \frac{\sum \boldsymbol{U_{gj}^i} * \boldsymbol{q_{gj}^i}}{\sum \boldsymbol{U_{gj}} * \boldsymbol{q_{gj}^i}} \tag{2}$$

and

$$\boldsymbol{L_j^i} = \frac{\sum \boldsymbol{U_{gj}^i} * \boldsymbol{q_{gj}}}{\sum \boldsymbol{U_{gj}} * \boldsymbol{q_{gj}}} \tag{3}$$

where U_{gj}^i is the unit value for the aggregate product *g* within food category *j* for household *i* as defined in (1), U_{gj} is the unit value for the aggregate product *g* within food category *j* for the average household, and q_{gj} is the average quantity purchased for aggregate product *g* within food category *j* for the average household; P_j^i and L_j^i represent the Laspeyres and Paasche price indices for individual *i*'s food group *j*, respectively.

3) In the final stage, we estimated the Fisher price indices (the geometric mean of the Laspeyeres and Paache indices) for each food group *j* and household *i* using:

$$\boldsymbol{F_j^i} = \sqrt{\boldsymbol{P_j^i} * \boldsymbol{L_j^i}} \tag{4}$$

Average expenditure shares and socio-demographic characteristics of the sample are also presented in Table 1. Sample characteristics on Table 1 shows that middle class households represent 41.53% of the sample, while households belonging to the higher and lower social classes represent 36.79% and 21.68%, respectively. In Spain, the percentage of lower, middle and upper class households were 33%, 55% and 12%, respectively, in 2016. Comparably, lower social class were under-represented while higher social class households were more over-represented in our data. Considering the BMI of the household head, underweight people were the minority (3.2%), while obese and overweight persons represented 42.59% of the total sample. These figures are close to those estimated for Catalonia's population in 2012 by the Public Health Department in

Barcelona[4]; 49% of the populace were overweight and obese. The variations show a slightly under-representation of overweight and obese persons in our data. Finally, households with kids formed the minority, represented by 34.20%, with the remaining being households without kids.

Include Table 1 here

Empirical Strategy

In the full EASI model (see Lewbel and Pendakur, 2009), the budget share, w_j of each food j is represented by:

$$w_j = \sum_{r=0}^{5} E_{rk} y^r + \sum_{l=0}^{L} A_{kj} z_l lnP_k + \sum_{k=1}^{J} B_{kj} lnP_k y + \sum_{l=0}^{L} (C_{lj} z_l + D_{lj} z_l y) + u_j \quad (5)$$

Where y is real food expenditure specified as:

$$y = ln(x) - \sum_{j=1}^{J} \ln(P_j) w_j + \frac{1}{2} \sum_{j=1}^{J} \sum_{k}^{K} A_{ij} \log(p_j) \log(p_k) \quad (6)$$

The regressors in (5) are a fifth-order polynomial in y, log prices lnP_k of each good k and L different demographic characteristics z_l, as well as interaction terms of the forms: $lnP_k y$, $z_l lnP_k$, and $z_l y$. Parameters to be estimated are A_{kj}, B_{kj}, C_{lj}, D_{lj} and E_{rj}. In other to ensure that (5) is homogenous of degree zero in prices, satisfy Slutsky symmetry, and adding up, we imposed the following restrictions:

$$A_{kj} = A_{jk} \text{ and } \sum_{k=1}^{J} A_{kj} = \sum_{k=1}^{J} A_{kj} = 0 \text{ for all k, j=1,….,J} \quad (7.1)$$

$$\sum_{i=1}^{L} C_{lj} z_l = \sum_{i=1}^{L} D_{ij} = 0, \text{ for all } i = 1……\text{L} \quad (7.2)$$

[4] https://www.diba.cat/es/web/entorn-urba-i-salut/sobrepes-i-obesitat

$\sum_{k=1}^{J} E_{kr} = 0$ for r=1,…..R and $\sum_{k=1}^{J} E_{kr}$ = 1 for r=0 (7.3)

Given that y is a function of the budget shares, endogeneity is an issue to be considered. Additionally, (6) appears on the right hand side of the budget share equations, making the system non-linear. Lewbel and pendakur (2009) proposed the use of non-linear GMM or an iterated linear approximation for the estimation of the parameters. Similar to Reaños and Wölfing (2018), we adopted the iterated linear approximation.

To deal with expenditure endogeneity in the estimation of the iterated linear approximate model, first, y in (5) was replaced by the Stone deflated real expenditure, $y = ln(x) - \sum_{k=1}^{J} \ln(P_{kj})\, w_j$, where A_{ij} has been set to zero, x_i is annual nominal household expenditure. Second, we estimated another Stone deflated real expenditure by setting A_{ij} in (6) to zero and the budget shares, w_j replaced with their sample average $\overline{w}_j$ leading to: $\tilde{y}_i = \ln(x) - \sum_{j=1}^{J} \ln(P_{kj})\, \overline{w}_j$ to instrument for food group expenditure (x).[5] The approximate EASI model consisted of 15 equations minus one was estimated using iterative linear three-stage least squares (3SLS).

Expenditure elasticities and Hicksian and Marshallian price elasticities were derived from (5) following Castellón et al. (2015) and Zhen et al. (2014).

- Hicksian elasticity of demand for good *k* with respect to the price of the good *j* was derived

as: $$\epsilon_{kj} = \frac{(z_l A_{kj} + B_{kj} y)}{w_k} + w_j - \delta_{kj} \tag{8}$$

where δ_{kj} =1 if *k* =j, and 0 otherwise.

[5] Zhen et al. (2014) show that this form of endogeneity can be handled by estimating an incomplete food-at-home demand model and ignoring the need to use instruments. However, this strategy needs information about household income, which is not available in our dataset.

- The vector of 15 food expenditure elasticities $\boldsymbol{\vartheta}$ were subsequently derived as:

$$\vartheta = (diag(\gamma))^{-1}[(I_j + \sigma\omega')^{-1}\sigma] + 1_j \tag{9}$$

where $\boldsymbol{\gamma}$ is the $J \times 1$ vector of observed budget shares, σ is a $J \times 1$ vector whose *n*-th element equals $\sum_{r=0}^{5} rE_{rj}y^{r-1} + \sum_{l=0}^{L} D_{lj}z_l + \sum_{k=1}^{J} B_{kj}P_k$, ω is the $J \times 1$ vector of log prices, and 1_j is a $J \times 1$ vector of ones.

- The Marshallian elasticity of demand, $\boldsymbol{\varepsilon_{kj}}$, was derived from the Slutsky equation using:

$$\varepsilon_{kj} = \epsilon_{kj} - w_j * \vartheta_n \tag{10}$$

where ϑ_n is the *n*-th element of ϑ**.**From the matrix of price and expenditure elasticities in (8–10) (see Huang, 1996), the matrix of nutrient elasticities Ψ can then be obtained by pre-multiplying the matrix of food aggregate nutrient shares ζ by the matrix of own and cross-price demand elasticities Θ.

$$\Psi = \zeta * \Theta \tag{11}$$

where $\boldsymbol{\Psi}$ is the *n x (j+1)* matrix of nutrient elasticities in response to changes in food prices and expenditure (*n* indicates the number of nutrients and *j* the number food products), $\boldsymbol{\zeta}$ is the *n x j* matrix with entries in each row indicating the food commodity's share of a particular nutrient, and $\boldsymbol{\Theta}$ is the *(j x j+1)* matrix of demand elasticities

The matrix of price and expenditure elasticities as well as the matrix of nutrient elasticities were used to analyze the effects of the policy reform on diet quality and nutrient distribution. Complete nutrient data[6] on all foods consumed in our data were obtained from the Spanish Food Composition Database (BEDCA)[7](see Table 2).

Include Table 2 here

Policy simulation scenarios

Following the work of Salois and Tiffin (2011), this study simulates a revenue-neutral tax policy where a VAT reform derived from the public cost of obesity is imposed on foods based on their saturated fat content, while subsidies are placed on selected foods that are untaxed. The threshold for imposing the taxes was set at 2.3% of saturated fat following the work of Jensen et al. (2016) (the threshold considered by the Danish Government when designing its fat tax in 2011). As mentioned in the introduction, we proposed an increase of the current value added tax (VAT scenario) to internalize the externalities (public health expenditure[8]) associated with obesity in Spain, which accounts for about 7% of total health expenditure (approximately 5 billion Euros). This is equivalent to an average damage cost of 0.30 Euros per capita per day. The damage cost was proportionally distributed based on the saturated fat content on all food categories with saturated fat exceeding 2.3%.

Hence, the tax imposed on each food category with saturated fat above 2.3% was calculated as:

$$VAT\ scenario: t_j = \xi_j * \tau_1 \tag{12}$$

[6] This was calculated as the weighted mean using the frequency of purchase as weights. The entire table, comprising the 44 nutrients and 15 food categories considered in our paper, are available upon request.
[7] Further information can be retrieved from http://www.bedca.net/bdpub/index.php.
[8] In 2016, the Spanish Health Expenditure was 71.48 billion Euros, with 7% representing 5 billion. From this calculation, in 2016 the government spent in excess of 5 billion on health due to direct and indirect consequences of obesity. See https://datosmacro.expansion.com/estado/gasto/espana

where ξ_j is the average saturated fat contained in food group *j*, τ_1 is the damage cost due to rate to the VAT tax.

In creating the revenue-neutral tax scheme, we followed the paper of Edjabou and Smed (2013) to estimate the price of the subsidized food aggregate *k*, P_{1k} as:

$$\boldsymbol{P_{1k} = p_{0k}} - \emptyset * \boldsymbol{P_{0k}} \tag{13}$$

where $\emptyset$[9] is a consistently positive factor and $\boldsymbol{P_{0k}}$ is the price of the *k*-th food category that was untaxed in VAT scenario (Table 2). Based on the above method, the subsidies ($\emptyset$) generated for the VAT scenarios $(\emptyset_{VAT}) = 1.49\%$. The taxes and subsidies computed are displayed in Table 2 (right hand column).

Calculating changes in nutrient intake

The percentage reduction in the quantity of nutrients consumed after the tax reform were calculated taking own- and cross-price elasticities into account. The post-tax change in the consumption of nutrients for the average household, $\frac{\Delta q_n}{q_n}$, taking into account own- and cross-price nutrient elasticities, was calculated as:

$$\frac{\Delta q_n}{q_n} = \sum_{k=1}^{J} \boldsymbol{\Psi_{kj}} * \frac{\Delta p_k}{p_k} \tag{14}$$

Where $\boldsymbol{\Psi_{kj}}$ is the own- and cross-nutrient elasticities of good *j* and $\frac{\Delta q_n}{q_n}$ is the percentage change in nutrient *n*.

Distributional effects on nutrient consumption

[9] The value of $\emptyset$ is determined as the subsidy that makes the total tax revenue from the taxed foods equal to zero.

The distributional effects of the tax reform on nutrient intake were analyzed following Leicester and Windmeijer (2004). The policy effects were analyzed in the context of changes (decline or increase) in both the consumption of selected essential macronutrients (protein, carbohydrate, lipids and protein) and micronutrients (cholesterol, saturated fats, mono-saturated fats, and sodium) for the average household head and two sociodemographic household segments i.e. the presence of kids and the body mass index (BMI) of the household head (see Table 1).

Welfare effects of the tax reform

The welfare effects were analyzed from the context of presence of kids and the BMI of the household head. To do this, we have implicitly assumed that food supply in this economy is perfectly elastic and that production decisions are not influenced by the VAT reform. Welfare estimates based on compensating variation were calculated using the log of living cost index (Lewbel and Pendakur, 2009) which takes into account both first-order and second-order effects. The log of living cost index for the average household can be estimated using:

$$\boldsymbol{C}(\boldsymbol{p_1},\boldsymbol{u},\boldsymbol{z},\boldsymbol{\varepsilon})-\boldsymbol{C}(\boldsymbol{p_0},\boldsymbol{u},\boldsymbol{z},\boldsymbol{\varepsilon})=(\boldsymbol{p_{k1}}-\boldsymbol{p_{k0}})'\boldsymbol{w_0}+\mathbf{0.5}(\boldsymbol{p_{k1}}-\boldsymbol{p_{k0}})'\left(\sum_j^N \boldsymbol{z_l A_{kj}}+\boldsymbol{B_{kj} y}\right)(\boldsymbol{p_{k1}}-\boldsymbol{p_{k0}}) \qquad (15)$$

The term $(\boldsymbol{p_{k1}}-\boldsymbol{p_{k0}})'\boldsymbol{w_0}$ in (6) is the Stone index for the price change while $\mathbf{0.5}(\boldsymbol{p_{k1}}-\boldsymbol{p_{k0}})'\left(\sum_j^N \boldsymbol{a_{kj}}+\boldsymbol{b_{kj}\tilde{y}}\right)(\boldsymbol{p_{k1}}-\boldsymbol{p_{k0}})$ models substitution effects resulting from price changes.

To estimate the welfare effects for the *n*-th social demographic group, we subsampled the data based on the *n*-th demographic group to estimate average budget shares, which were introduced into equation (15).

3. Results and Discussion

Model estimation and nutrient elasticities

We have applied the approximate EASI demand model for the estimation of incomplete food-at-home demand system for Catalonian households. Sociodemographic variables that were included in the model were presence of kids, body mass index, age and social class of the respondents. Interactions between price and expenditure, expenditure and social class and social class and price were also included in the model. Robust checks were carried out to determine the proper degree of expenditure polynomials to be included in the model. A quartic functional form (r=4) is appropriate to capture the curvature of the Engel curves pointing to non-linear Engel curves among some food groups. Ignoring such nonlinearities could lead to important distortions in the estimation of welfare losses for our tax policy.

The nutrient expenditure elasticities allows us to measure the percentage change in nutrient intake due to a 1% change in household expenditure resulting from the tax imposition[10]. For the average household, our results indicate that protein, potassium, iron, iodine, vitamin A, vitamin D, vitamin E, vitamin C, vitamin B6, folate acid, riboflavin, thiamin, and cholesterol are expenditure elastic, while all other nutrients are expenditure inelastic. Considering the impact of price changes on the demand for nutrients, the results indicate that an increase in the price of all animal protein categories will reduce the consumption of cholesterol and fat; (Huang, 1996)also found a similar result for all animal protein sources. Food as well as nutrient prices therefore have important implications for the increasing prevalence of obesity (Powell and Chaloupka, 2009). For instance, the inelastic expenditure elasticity of lipids and saturated fats has implications for population

[10] Results are not presented due to space limitations but are available upon request

health. First, any policy targeted at these nutrients will yield very small results as consumers hardly respond to budget changes. In addition, the elasticities seem to suggest that taxes may be ineffective compared to physical exercise.

Similar to Huang (1996), we find that increasing the price of vegetables and vegetable products, as well as fruit and fruit products will reduce the consumption of all types of minerals and vitamins. This has implication for government policies targeted at increasing the consumption of vitamins and minerals through subsidy policies. Subsidies on fruit and vegetables present the best option to improve consumer diet. Similarly, an increase in the price of all animal sources of protein, milk and dairy product imitates and cheese will lead to a reduction in the consumption of lipids, saturated fat, and cholesterol. These nutrients have been shown to be partly responsible for the high risk of ischaemic heart disease, obesity etc. (Alemanno and Carreño, 2011; Marshall et al., 2000). Our results reinforces the use of fat and sugar taxes to combat health related diseases in countries such Denmark (Smed et al., 2016) and Mexico (Colchero et al., 2016).

Impact on diet quality

In Spain, the Estrategia para la Nutrición, Actividad Física y Prevención de la Obesidad (NAOS) (2005) recommended a maximum protein intake of 15% of total calories; total fat (lipids) not exceeding 30% of the total daily calorie intake; and an average daily carbohydrate intake representing 55% of total calorie intake. Based on these estimates, we compare recommended average per capita adult equivalent nutrient ratios with pre- and post- tax nutrient ratios. From Figure 1, starting from the bottom, the first group of bars correspond to protein consumption, followed by lipid and carbohydrate consumption. Each group of nutrient has three bars, the first bar corresponds to the recommended nutrient intake ratio by NAOS, the second bar correspond to the actual nutrient intake ratio and the third bar correspond to the post-tax nutrient intake ratio. The current average Spanish diet is clearly unbalanced, lipid and protein intake are over their recommended values, representing (44.49>30%) and (19.86>15%) of total daily caloric intake. The carbohydrate intake, on the other hand, is lower than the recommended value (35.64<55%) of total daily caloric intake. Our values support studies that found that, in Europe, the proportion of fat is higher at the expense of carbohydrates (Balanza et al., 2007). We show that imposing the fat tax on nutrient demand results in macronutrients redistribution toward the recommended NAOS ratios. On the positive side, the ratio of lipids in total calorie intake decreased by 0.93%. In addition, the ratio of carbohydrate increased by 1.16%. On the negative side, the calorie intake from protein appreciated by 0.36%. Since the objective of the tax was internalizing the damage cost of obesity, it can be concluded that the policy is effective; however, the impact of the tax policy on health is debatable. Tiffin and Arnoult (2010) also concluded that taxing saturated fat (0.00–15.00%) and subsidizing fruits (14.78%) was insufficient to achieve the goal of nutrient redistribution in the UK. In any case, the taxes and subsidies imposed in this study were lower: 1.22 - 7.68% for taxes and 1.49% for subsidies. The effect of macronutrient redistribution on health i.e. is still inconclusive (Vergnaud et al., 2013). A study by Kim and Song (2019) relating changes in macronutrient ratios to the prevalence of obesity in Japan concluded that macronutrient redistribution has no significant effect on the prevalence of obesity. However, according to Vergnaud et al (2013), a higher proportion of energy from protein at the expense of carbohydrates/lipid (as in our cases) is positively associated with weight gain. Therefore, policies should not be directed towards lipids/fats only but also directed towards reducing total caloric intake from protein.

Paste Figure 1 here

The impact of the tax is also analyzed in the context of changes in micronutrient intake, such as sodium, saturated fat, mono-unsaturated fatty acid, poly-unsaturated fatty acid and cholesterol, which have been proven to be associated with the prevalence of some types of diabetes and cardiovascular diseases. Figure 2 indicates that with the highest tax of 7.7%, the consumption of saturated fats, mono-unsaturated fatty acid, sodium and cholesterol would decrease by 1.39%, 1.22%, 0.58% and 0.61%, respectively. Reductions in saturated fat and cholesterol could reduce the risk of atherosclerotic coronary heart disease (CHD) (DiNicolantonio et al., 2018). There is therefore the need to strengthen policies target at reducing saturated fat and cholesterol intake.

However, the decline in the consumption of saturated fat and cholesterol is offset by the decline in the consumption of beneficial fatty acid – poly-unsaturated fatty acid – by 0.93%. This is because products with relatively high poly-unsaturated fatty acid are usually the main sources of saturated fatty acids. The revenue-neutral VAT policy reform would also have a significantly positive influence on non-targeted nutrients such us dietary fiber, iron, vitamin C, potassium, magnesium, vitamin B6, alpha and beta-carotene. In summary, a tax policy based on the damage cost of obesity could lead to a marginal reduction of health threatening nutrients.

Paste Figure 2 here

Distributional impact of the fat tax

<u>Presence of kids in the household</u>

On the average, the impact of the tax is higher among household heads with kids older than 5 years. From Figure 3, all household types will benefit from the tax. The consumption of lipid will decline towards the consumption of carbohydrate. More specifically, the reduction in lipid intake is highest among household heads with kids above 5 years. In the case of carbohydrate, consumption increased across all household head types - highest among household heads without kids. These results have some policy implications. First, revenue-neutral fat taxes could lead to substitution of fat for carbohydrate across all household types. Second, households with high-energy requirement respond more to the tax policy. On the other hand, households with minimal energy requirement will respond more to the subsidy.

Among all the micronutrients, saturated fat recorded the highest decrease across all household segments. This is in the right direction as the tax is targeted at foods with high saturated fat content. This suggest that a nutrient tax will produce targeted results than a food tax policy. Although the effect of the tax was marginal, we cannot ignore the positive impact of the tax/subsidy schemes across all household segments especially on saturated fat and total lipid intake.

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<u>BMI of household heads</u>

In general, the tax policy reform would be effective. There was a significant substitution of lipid for carbohydrate among both obese and overweight household heads (see Figure 4). For instance, lipid intake reduced by 1.18% for overweight persons and 1.17% for obese persons. The policy is, therefore, more effective on person at risk of becoming obese (Powell and Chaloupka, 2009). Moreover, carbohydrate intake increased by 0.93% for obese and by 1.09% for overweight persons. It can be concluded that taxing foods perceived as being associated with obesity as a policy instrument can promote healthier diets (Maniadakis et al., 2013).

In terms of the micronutrient intake, the VAT policy reform would improve the quality of diet of all the BMI groups by reducing cholesterol, sodium and saturated fat intake especially for persons with obesity. The tax policy will have a greater impact on obese and overweight persons, which is desirable. Despite the positive effects of the tax policy on nutrient demand, there are unintended negative health effects i.e. reduction in polyunsaturated fatty acid (Salois and Tiffin, 2011).

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Exegesis

The revenue-neutral fat tax imposed in this study will results in 1.39% reduction in saturated fats, on the average. Post-tax analysis of the fat tax in Denmark suggest that fat taxes make positive, although minimal contributions to public policies (Smed et al., 2016). This figure should not underscore the potential effectiveness of the policy. In fact, literature support that sustained minimal reductions in daily dietary fat can reduce body weight (Siggaard, Raben and Astrup, 1996; Swinburg et al., 1997). Yu-Poth et al. (1999) supported this view by showing that a 1% reduction in energy from total fat could lead to 0.28 kg decrease in body weight. Similarly, from a meta-analysis, Astrup et al. (2000) showed that a 1% reduction in dietary fat could lead to weight loss of about 0.37 kg (95% CI, 0.15 to 0.6 kg).

Welfare Effects of the Fat Tax

Welfare effects are displayed on Figure 5. The effect of the tax on food expenditure is almost negligible. For instance, initial average food expenditure will increase by 0.09% for the average household head. This does not support literature that suggest that revenue-neutral food tax reforms would be heavily regressive on consumers (Allais et al., 2010). From the distributional perspective, household heads with kids older than 5 years, households without kids would spend more on their food expenditure than households with kids. From the BMI context, the impact of the tax is not proportional. For instance, underweight and overweight persons would be more affected by the policy than normal weight and obese persons. In conclusion, internalizing the damage cost of obesity will put economic burden on the average individual as well as different socio-demographic groups.

4. Conclusion

Regulatory policies in Spain have not been very effective in reducing the prevalence of overweight and obesity. As a result, some researchers and health policy advocates have begun to demand the use of market intervention policies to tackle unhealthy dietary habits related to unbalanced sugar and saturated fat intake. As such, the aim of this paper was to assess the potential effectiveness of internalizing the damage cost of obesity through a revenue-neutral VAT reform (fat tax scheme) in Spain. Distributional effects on household heads with/out kids and BMI of household heads were also assessed. These two groups were considered due to the increasing importance of obesity among adults and children.

To achieve our objective, we modified the VAT of fat rich food products to include a tax rate that internalizes the direct and indirect public health cost associated with obesity and related diseases. Revenues from taxed products were used to subsidize healthier products taking into account their saturated fat content. The methodological framework was based on demand analysis by estimating food demand and nutrient intake elasticities.

The results found in this paper suggest that the impact of a revenue-neutral fat tax could improve diet quality, although not in the very short term. In any case, the main objective was to internalize the health costs associated with obesity. Although the improvements are limited, they do move in the right direction and can contribute to shaping behaviors in the medium-term. In fact, the fat tax would contribute marginally to reducing the current imbalance in macronutrient ratios by effectively reducing (increasing) the lipids (carbohydrates) intake. Moreover, it would decrease the consumption of saturated fatty acid, sodium, and cholesterol. On the negative side, it would significantly decrease the poly-unsaturated fatty acid intake. This tradeoff suggests that, subsidies based on poly-unsaturated fat content of foods could suffice.

The distributional effects of the tax policy have been measured on the basis of positive (negative) changes in macro- and micro-nutrient intake that are beneficial (detrimental) to the health of population segments based on age and BMI. One interesting result from this paper is that the tax is more effective for persons with obesity and overweight. Consequently, it is more effective in those age groups in which the prevalence of overweight and obesity is higher. Welfare analysis in this paper suggest that internalizing the damage cost of obesity does not impose any economic burden on consumers, rather, the revenue-neutral nature of the tax results in expenditure savings for all household segments.

From the poly perspective, our result is a strong advocate for revenue-neutral "Pigovian" tax policy. This means that government policies should be directed towards the good that is the main cause of the externality. We have shown that there is an overconsumption of dietary lipid among our subjects. Imposing a direct tax on dietary lipid led to marginal but efficient nutrient redistribution. The substitution of lipid for carbohydrate suggests that the tax policy has been efficient. Countries like Denmark, Mexico, some states in the USA have found similar results. Our results therefore reinforces the use of nutrient tax policies such as fat and sugar taxes to combat health related diseases.

A nutrient tax policies is a necessary but insufficient tool for significant short term changes. This is because the effect of the tax on consumption/nutrient redistribution is usually marginal. Imposing a huge tax outside the market variation of prices is also not politically feasible. There is therefore the need to complement tax policies with regulatory policies. In Spain, regulatory policies include restriction on advertisement, compulsory inclusion of vegetables and fruit in diet in schools, education on the need for exercise etc. Regulatory policies alone have failed to reduce the prevalence rates of overweight and obesity. This makes the use of fiscal policies a necessary tool since consumers are usually loss averse.

Nutrient policies may have unintended consequences on diet. We have shown that targeted nutrient policies have the tendency to reduce the consumption of the nutrient in question. However, due to substitution among nutrients when prices are altered, the policy can increase the consumption of macro – and/or –micronutrient that are detrimental to health when consumed in large quantities. For instance, we have shown that the reduction is lipid intake results in an increase in protein intake above the recommended level. Similarly, the decrease in saturated fat is offset by a decrease in polyunsaturated fat. A post-tax analysis of the Denmark fat tax found a similar result. However, most studies calling for nutrient tax policies do not take into account these unintended effects.

Nutrient policies has been found to have marginal effect on dietary fat but efficient for weight reduction. Most researchers are divided on the long-term effect of nutrient taxes on body weight. However, clinical studies support the importance of small changes in total dietary fat on body weight reduction. These results are important for policy makers aimed at reducing the prevalence of obesity.

Nutrient tax policies may be beneficial for health but the welfare effects are disproportionate according weight. Taxing saturated fat do not impose greater cost both underweight and overweight persons. Literature also found food and nutrient taxes to be more regressive on low-income people. Such a disproportionate impacts cannot be ignore when designing nutrient policies. Government and policy makers must take into consideration such effects when designing nutrient taxes. However, we are unable to ascertain this result in other countries since this is the first study considering the effect of nutrient taxes on body weight.

Although this paper has aimed to contribute to the current policy discussion about the implementation of fiscal policies to improve the current health status of the population, we must note that the results should be interpreted with caution. First, although most of the relevant food categories are included, our dataset does not record household income and food-away-from-home expenditure; consequently, the results are based on conditional food-at-home demand elasticities. Finally, we have assumed a perfectly elastic supply curve, which could be relaxed in the future.

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Table 1 Food expenditure shares and socioeconomic characteristics of households

	Variable	Mean	Std. Dev	Percentage of Zero Purchases
Expenditure Shares	Grains and grain-based products	6.74	3.81	0.0
	Vegetables and vegetable products	13.88	6.95	0.0
	Starchy roots, tubers, legumes, nuts and oilseeds	1.46	1.14	0.2
	Fruit and fruit products	22.09	9.47	0.0
	Beef, veal and lamb	2.20	1.66	2.1
	Pork	1.99	1.45	0.5
	Poultry, eggs, other fresh meat	6.72	6.82	0.3
	Processed meat products	3.98	2.38	0.0
	Fish and seafood	4.92	2.79	0.2
	Milk and dairy products	18.62	9.13	0.0
	Cheese	2.57	1.59	0.2
	Sugar and confectionary and prepared desserts	6.01	3.77	0.0
	Plant-based fats	2.65	1.78	1.8
	Composite dishes	5.38	4.13	0.5
	Snacks and other foods	0.79	0.77	2.4
	Log of real expenditure	6.82	0.46	
Socio-demographics	Low social class	21.68	0.41	
	Lower middle social class	20.31	0.40	
	Middle social class	21.22	0.41	
	High social class	36.79	0.48	
	18–34 years	5.65	0.23	
	35–49 years	41.68	0.49	
	50–64 years	35.27	0.48	
	60+ years	17.40	0.38	
	Presence of children 0-5 years	13.28	0.34	
	Presence of children 5+ years	20.92	0.41	
	No children	65.80	0.47	
	Underweight	3.21	0.18	
	Normal weight	54.20	0.50	
	Overweight	14.35	0.35	
	Obese	28.24	0.45	

Source: Author's own computation, 2018

Table 2 Tax and subsidy simulation scenarios

Food Categories	Fat tax Scenario		
	Average Consumption (grams/person/day)	Average saturated fat content (gram/100g)	Taxes / Subsidies
Grains and grain-based products	98.23	1.23	-1.49%
Vegetables and vegetable products	217.19	0.13	-1.49%
Starchy roots, tubers, legumes, nuts and oilseeds	23.82	0.89	-1.49%
Fruit, fruit products and fruit and vegetable juices	336.14	0.06	-1.49%
Beef, veal and lamb	31.83	3.83	1.86%
Pork	29.35	4.36	1.99%
Poultry, eggs, other fresh meat	109.97	2.13	-1.49%
Processed and other cooked meats	56.36	11.39	5.35%
Fish and other seafood	73.75	1.31	-1.49%
Milk, dairy products and milk product imitates	305.63	2.30	1.04%
Cheese	35.93	16.09	7.68%
Sugar and confectionary and prepared desserts	86.17	5.86	2.71%
Plant-based fats	38.22	13.18	6.23%
Composite dishes	87.47	1.92	-1.49%
Snacks and other foods	10.42	2.60	1.22%

Source: Author's own computation, 2018

Figure 1 Post tax effects of internalizing the social cost of obesity on average household dietary ratios

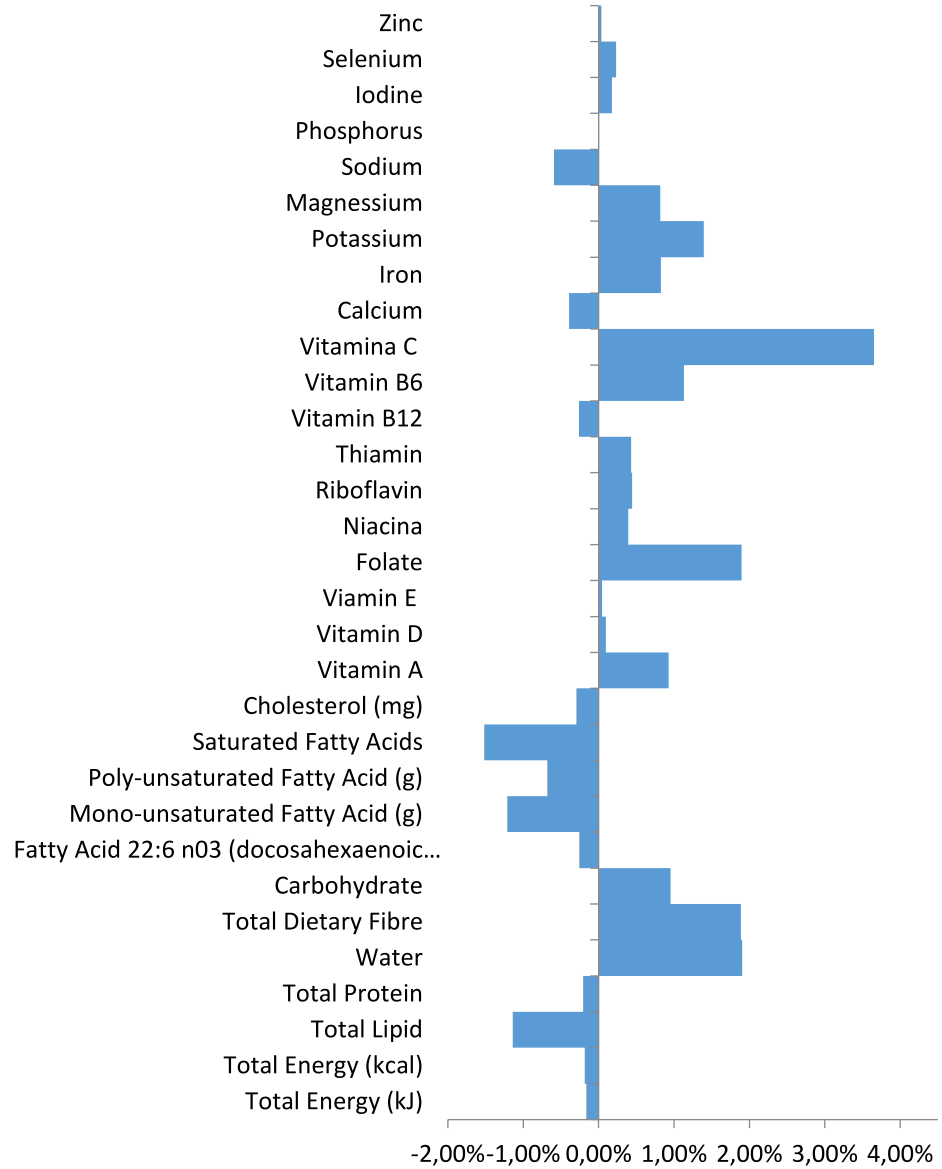

Figure 2 Impact of tax policies on nutrient distribution

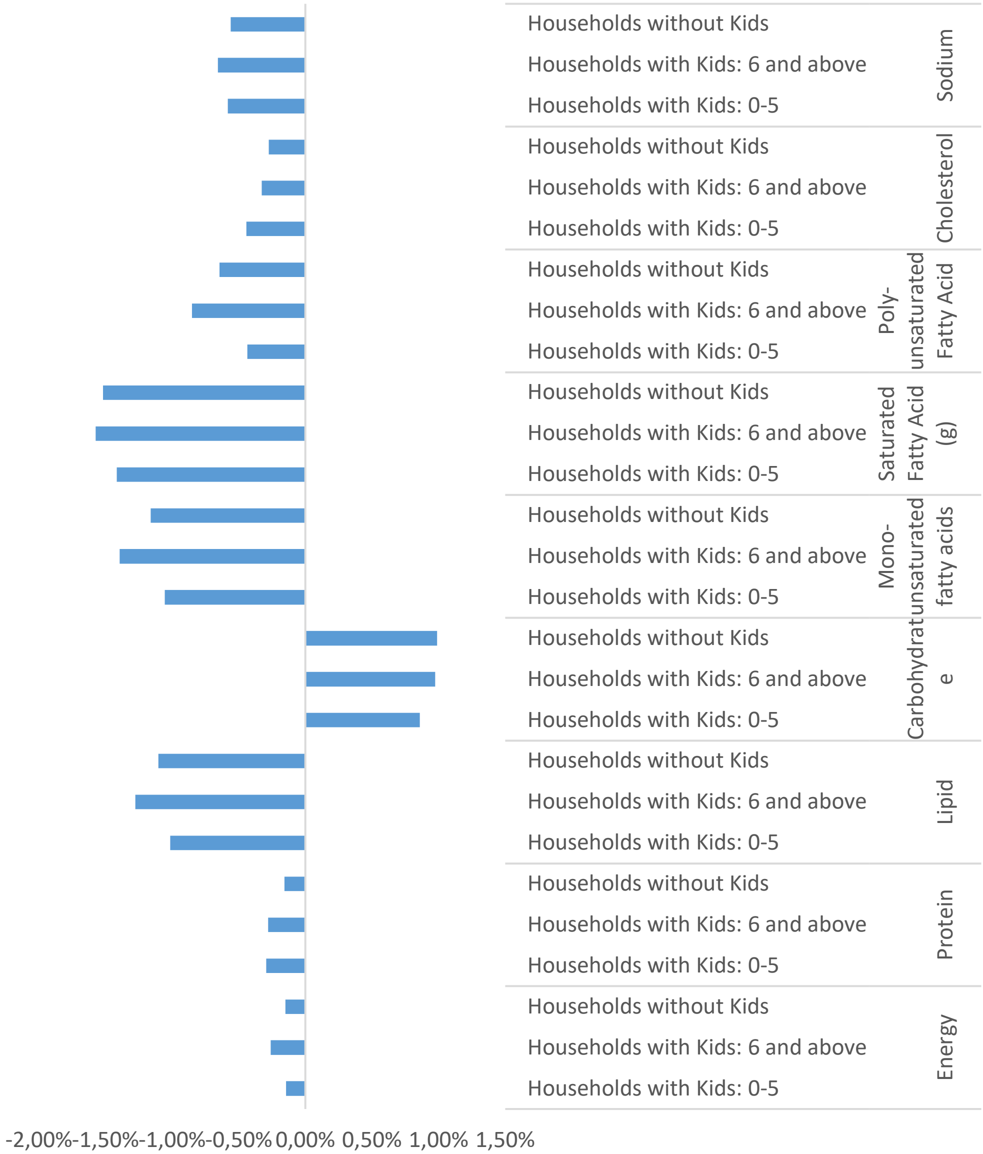

Figure 3 Post tax effects of internalizing the social cost of obesity on households with/out kids

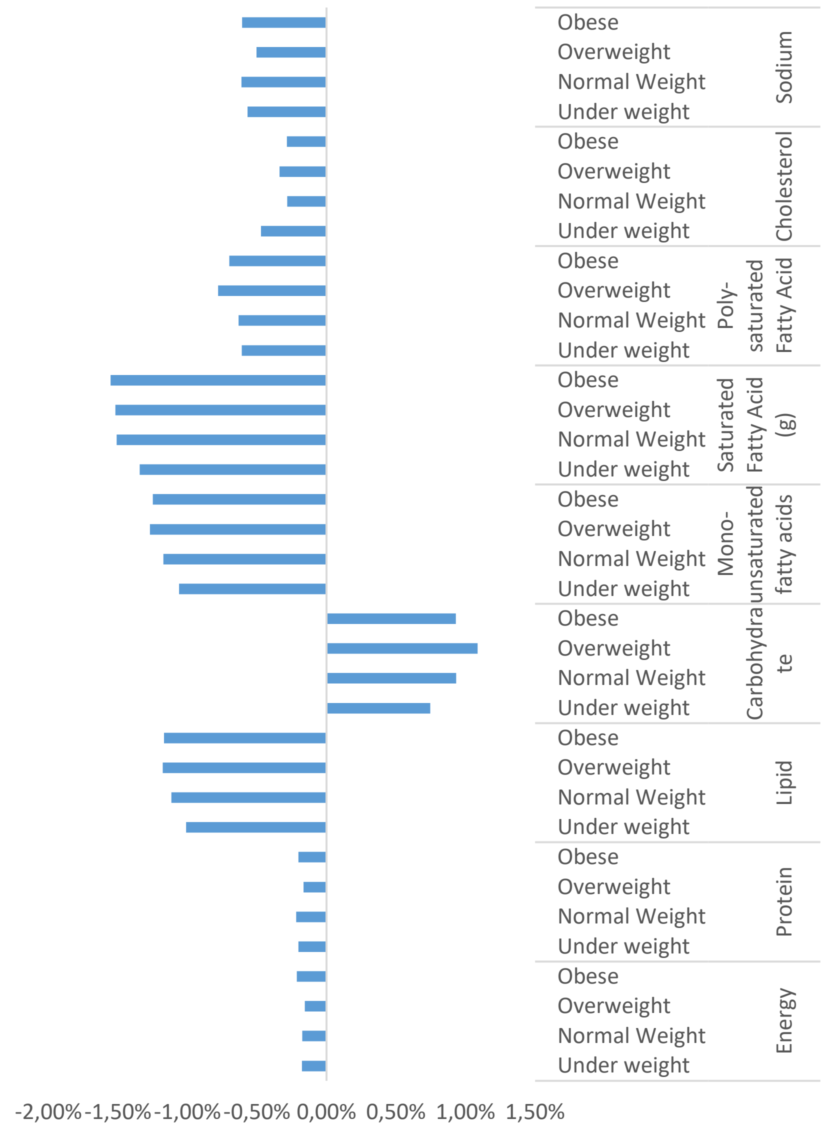

Figure 4 Post tax effects of internalizing the social cost of obesity across different weights segments

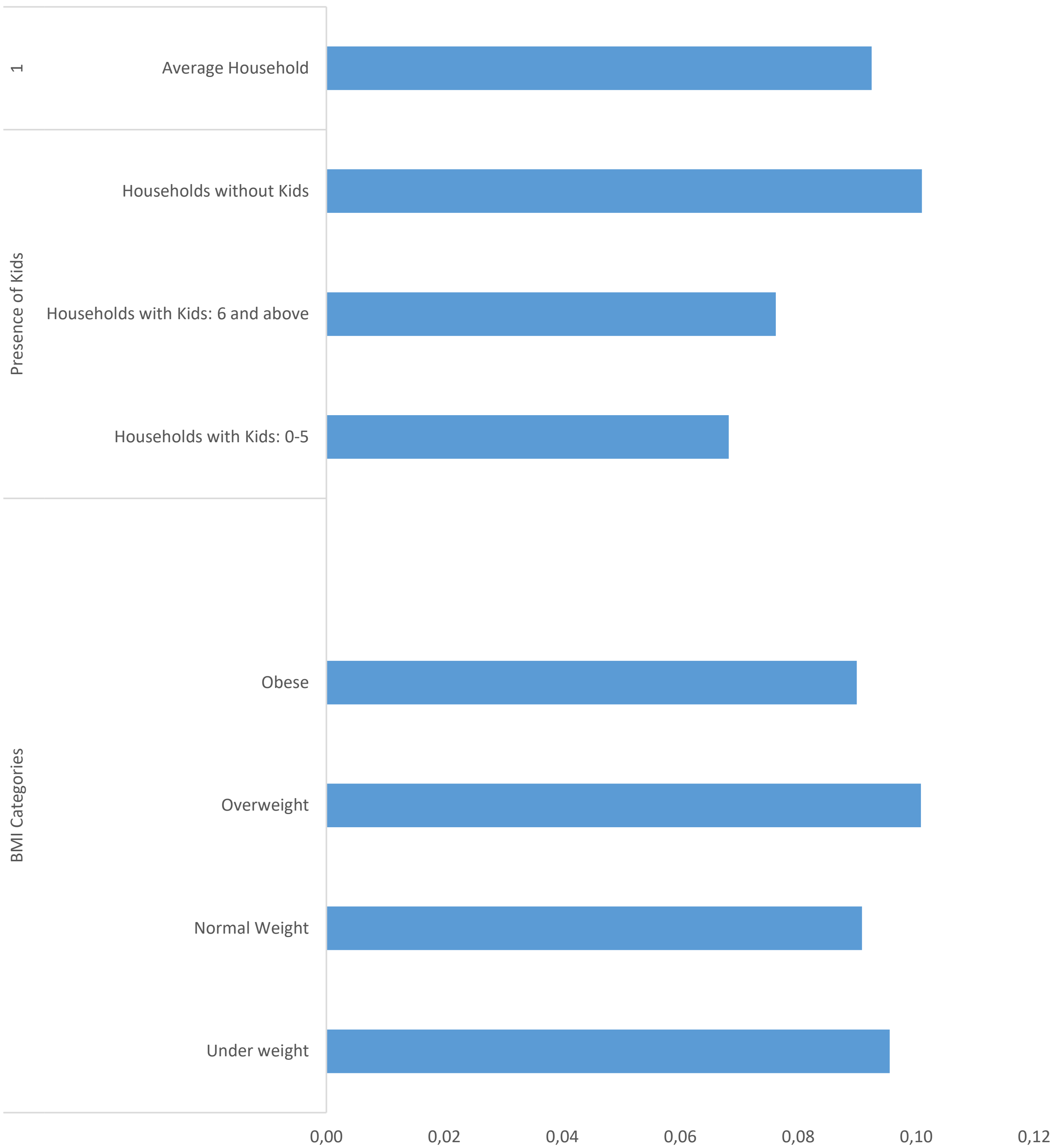

Figure 5 Distributional increase in daily tax on food expenditure due to the tax policy