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Can Price Intervention Policies Improve Diet Quality in Spain?

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In this paper we estimate consumer demand for food taking into account some socio-demographic characteristics of consumers. To tackle the issue of unobserved heterogeneity among consumers we used the, recent developed, Exact Affine Stone Index (EASI) demand system. Data used come from matching two datasets: the National Expenditure and the National Health Surveys for Spain. The main objective of our paper is to examine the effect of different price intervention policies that aim to improve diet quality. These policies include taxing unhealthy foods (e.g. sweets; fat), subsidizing healthy foods (e.g. Fruit and vegetable) and a mixture policy that include taxing unhealthy and subsidizing healthy foods at the same time. Our results consistent with the literature suggesting that taxes (subsidies) have a significant but small effect on diet quality. However, taxes can increase public budget significantly which can be used to finance other policies as educational campaigns or complementary health policies.





1. Introduction

Poor diets and rising obesity rates dominate the current food, nutrition and health policy debate in many countries including Spain. Obesity is partly a result of an energy imbalance caused by the excessive consumption and/or low expenditures (i.e., low physical activity) of calories over a considerable period of time. Consequently, most published economic research has examined the increased growth of obesity rates by analyzing several factors that may contribute to this imbalance of caloric consumption and usage (see Cutler et al., 2003; Chou et al., 2004; Lakdawalla and Philipson, 2007; Philipson and Posner, 1999; Loureiro and Nayga, 2005).

Due to rising concerns about obesity, the availability, accessibility and choice of foods to meet an adequate diet are becoming key challenges to our food system today. Good nutrition is essential to obtaining optimum health and productivity and in reducing the risk of chronic and infectious diseases (Eastwood et al. 1984; Vining 2008). Understanding the factors influencing food consumption and obesity is needed to gain a clearer picture of the mechanisms that would cause individuals to eat unhealthful or become overweight. Hence, knowledge about how people make food choices and how economic and non-economic factors influence food consumption and obesity is critically important to improve policy interventions and developing agricultural and food programs that can assure a safe, affordable, reliable and nutritious food supply and promote health.

Understanding why obese people make different choices is essential to developing a reasoned policy approach to obesity. Then, the main objectives of this paper is to study the impacts of taxing (subsidizing) different food groups on diet quality and consequently on obesity.

In the estimation of our demand system we used a unique data base of hypothetical average consumers. Those hypothetical consumers were obtained through the merge of the Spanish National Health Survey and the Spanish Household Budget survey for the year 2012.

Bonnet (2013) argued that, the failure of public information campaigns have in reversing the mounting trend in obesity, lead economists to support food taxes to potentially force individuals to change their eating behavior and make the agro-food industry think more about healthy food



products. Our paper is considered the first attempt to evaluate the effect of such food taxes (subsidies) on food demand in Spain.

Furthermore, our paper stands out by being one of the first empirical applications of the new and promising demand system, EASI (Lewbel and Pendakur, 2009). In our paper we estimate an EASI demand system for the full diet of the Spanish consumers incorporating the weight status of the individual approximated by the Body Mass Index (BMI). The main advantage of EASI is the derivation of Implicit Marshallian demands, which allow benefiting from desirable features of both Hicksian and Marshallian demands. Similar to the Almost Ideal Demand system (AIDS), budget shares in EASI are linear in parameters. In deference with AIDS, EASI can, however, have any rank and its Engel curves can have any shape over real expenditures. Moreover, EASI error terms can be interpreted as unobserved preference heterogeneity. In this study, price, income, BMI, age and gender elasticities were calculated and the results were used to assess the potential impact of market intervention policies on food demand and the prevalence of obesity in Spain.

To attain our objective, the rest of the paper is organized as follows. Section 2 provides a brief description on the obesity prevalence and food consumption in Spain. In section 3, a brief review of the literature on food price intervention policies is presented. The methodological approach applied in the analysis is explained in section 4. Our empirical application and the main results are discussed in sections 5 and 6, respectively. Finally, the paper ends with some concluding remarks.

2. Obesity prevalence and food consumption in Spain

Obesity is considered as a complex, multi factorial, chronic disease involving genetic, prenatal, dietetic, socioeconomic, and environmental components. Worldwide prevalence of obesity nearly doubled between 1980 and 2008. In Europe, the regional office of the World Health Organization (WHO) estimated that, in 2008, over 50% of both men and women were overweight, and roughly 23% of women and 20% of men were obese. These estimates indicate



that obesity prevalence in Europe in the last two decades has tripled affecting more than 150 million adults and 15 million children and adolescents in the region.

In Spain, the last National Health Survey (NHS) for 2011-12 (INE, 2013) indicated that the prevalence of overweight and obesity among Spanish adults aged 18 and over was 36.7% and 17.0%, respectively. While the prevalence of obesity was quite similar between men and women (18% among men and 16% among women), the overweight prevalence was significantly higher among men (45%) than among women (28%). Obesity was found to be associated with age. In the age segment between 18 and 24 years old, its prevalence merely reached 5.5% for both genders. On the contrary, in the segment between 65 and 74 years old the prevalence of obesity reached 25.6% and 27.9% among men and women, respectively (although it is true that it decreases for the eldest segments). There was also a significant negative relationship between education level and obesity. In fact, the highest percentage (30.0%) was found among illiterate persons. Also significant differences were found among geographical location and urbanization. For instance, the prevalence of obesity was found to be more important in Galicia, Andalucía and the Canary Islands and in rural areas.

From a historical perspective, it is worth mentioning that, in spite of the up to now relative low percentages in comparison with other EU countries, the prevalence of obesity in Spain has increased with a very alarming rate over the last 25 years moving from 6.9% and 7.9% among men and women, respectively, in 1987, to 18% and 16%, in 2012.

The Spanish National Survey of Dietary Intake (ENIDE) (2011) concluded that obesity rates in Spain was not due to eating too much (daily energy intake was 2482 kcal, slightly lower than the recommended level between 2550 and 2600 calories, depending on the individual's physical activity), but to the unbalanced diet characterized by the overconsumption of red meat, sodas and pastries. Furthermore, according to the Spanish Food Safety Agency (AESAs), food habits have changed with a significant reduction of both family meals and the time allocated to eat during weekdays which lead to a higher consumption of unhealthy calorie dense poor nutritious foods.

Noticeably, the prevalence of obesity has increased during the financial crisis that started to affect Spanish households in 2009 and more intensively during 2010. Comparing the data from the last two National Health Surveys (2006 and 2012), the obesity rate significantly increased



from 15.6% to 18%, among males but not as much among women (from 15.2% to 16%). This result has to do with a lower consumption of fresh foods, fruits and vegetables and a higher consumption of fast food, ready-to-eat meals and fatty foods, which have been relatively much cheaper (Rao et al., 2013). This situation is likely to continue in the future as the OECD predicted that the number of overweight and obese people in Spain will rise by a further 10 per cent over the next decade.

According to data from the Household National Expenditure Survey for 2012, the share for food and nonalcoholic beverages represents 14.71% of the total expenditure by the Spanish household with an average annual expenditure of 4140 (1617) euros per household (person). The average budget shares of different food groups in relation to total food expenditure were: bread and cereals, 15%; meat, 25%; milk and dairy products, 12%; fruits and vegetables, 19%; fish, 13%; fat and vegetable oils, 4% sugar and sweets, 4% ; and, finally, other food, 8%. However, important family differences appear in relation to certain household characteristics. In larger towns, households spend a relative higher percentage of their expenditure on fish, fruits and vegetables and meat, while the consumption of cereals and potatoes, dairy products and vegetable oils are lower. In relation to the education level, it is interesting to note that as the level of education increases, the relative importance of the consumption of cereals and potatoes and vegetable oils diminishes, being more significant in the first case. On the opposite side, higher education levels were found to be associated with higher budget shares allocated to meat, fish and fruits and vegetables.

In general, households with children had a higher budget share for cereals and potatoes, meat and dairy products. On the other hand, the percentage allocated to vegetable oils and fruits and vegetables was higher in one-person households and in households without children. In relation to the age of the head of the household, there existed a positive relationship between age and the consumption of fruits and vegetables and vegetable oils, while younger households were associated with higher budget shares allocated to cereals and potatoes, meat and fish. Finally, no big differences were found when accounting for the sex of the head of the household.



3. Food prices intervention policies

Dealing with the alarming and growing public health burden of obesity need a comprehensive and a well-designed combination of regulatory, educational agricultural and of course economic policies. Without any doubt economic interventions by themselves are not the magic solution for the obesity puzzle but should be considered one of the most important components of such integrated approach.

Mazzocchi and Traill (2006) classify the wide range of potential instruments available to public authorities in four groups according to their expected impacts on economic agents: 1) policies addressed to change consumer utility function; 2) those aimed at a better-informed choice without changing the utility function; 3) market measures addressed to affect actual choices without changing the utility function; and 4) supply-side policies affecting food availability. As shown by these authors, the number of potential alternatives is very large and, at the same time, they are very heterogeneous in nature, which, on the other hand, merely reflects the complexity of the problem and the number of factors influencing dietary habits and intakes (individuals' socioeconomic characteristics and lifestyles). Moreover, it is also true that food policies addressed to the emerging nutrition challenges need to coexist with agricultural and trade policies, which have traditionally regulated the agro-food activities with very different objectives. Such coexistence may reduce the effectiveness and complicate the implementation of some of the instruments.

Bonnet (2013) argued that, the failure of public information campaigns have in reversing the mounting trend in obesity, lead economists to support food taxes to potentially force individuals to change their eating behavior and make the agro-food industry think more about healthy food products.

Faulkner et al. (2011) conducted a scoping review with the aim of synthesizing existing evidence regarding the impact of economic policies targeting obesity and its causal behaviors (diet, physical activity). Their results proposed that, consistent evidence that weight outcomes are responsive to food and beverage prices and the relatively modest impact any specific economic instrument would have on obesity independently. Shemilt et al. (2013) conducted a scoping review analyzing the use of economic instruments to promote dietary and physical activity



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behavior change. Shemilt et al. (2013) defined economic instruments as “ it encompasses fiscal or legislative government policies designed to change the relative prices of goods or services or people’s disposable income, and promotional practices used by retailers to change the relative prices of goods and services”.

A tax on food, especially junk, has been suggested. People have developed unhealthy habits in response to the low price of food, especially calorie dense foods, and the low relative price of driving a car for transportation. However, these habits could be changed by altering the structure of economic incentives on which people base their decisions. Economic policies could be used to create incentives to both reduce excess calorie consumption and excessive reliance on the automobile (Senauer and Gemma, 2006). Modeling a tax rate similar to that on tobacco products, of approximately 58%, the researchers found a greater weight loss would be achieved. The acceptability of taxes at this level is not Clear (Fletcher et al., 2010). Imposing such high tax level in the case of food could be considered a quite challenging task as eating is both an absolute necessity and intrinsically healthy, whereas smoking have been shown to pose serious health risks. Because of that, a direct tax on food, even on high calorie foods low in nutrients, for the purpose of reducing obesity is not politically feasible. Additionally, a tax on food is regressive, since those with lower incomes spend a large share of their budget on food. A solution for this social and political unacceptability could be solved through combining such food tax with a food subsidy on healthy food which assure reducing the effect on the poor and granted a higher political acceptance.

Lakdawalla and Philipson (2001) inspect how food taxation may impact BMI. They find that higher food taxation (relative to the taxation of other goods) increases the price of food, and this increase in the relative food price will decrease BMI. Schroeter et al. (2008) simulate the impact that changes in taxes or subsidies for food and drinks would have on body weight finding that a tax on food away from home or a subsidy of vegetables and fruits would increase body weight while a tax on regular soft drinks or a subsidy of diet soft drinks would lower body weight. The result that an increase in the tax on food away from home would increase the body weight appears surprising. However, the tax on food away from home does in fact decrease away-from-home food consumption, but it increases at home food consumption (e.g. processed food) due to the fact that the two categories are substitutes. Because many of the foods consumed at home are



energy- rich, total consumption actually increases. Etilé (2008) estimates for French household survey data the impact of a 10% price decrease in fruits and vegetables on body weight and the impact of a 10% price increase in soft drinks, pastries, deserts, snacks and ready-meals on body weight. He then simulates the impact of five policy scenarios (taxes and subsidies) on the overweight and obesity prevalence. The authors find that with every of the five policy scenarios the distribution of BMI in the population is clearly more favorable in a public- health sense.

It is well accepted that, Excess intake of sugar sweetened beverages (SSBs) has been shown to result in weight gain. To address the growing obesity epidemic, one option is to combine programs that target individual behavior change with a fiscal policy such as excise tax on SSBs (Escobar et al., 2013). Sugary drinks have raised concerns as some evidence suggests that US children are gaining more calories from drinks than from food. In the US, an economic review found that soft drinks tax resulted in weight loss at different levels for different groups. However, weight loss was generally quite low at current (low, mean 3.3%) tax rates and insufficient to counter obesity (Fletcher et al., 2010). A tax on caloric sweetened beverages is justified for many reasons. Unlike fast foods, caloric sweetened beverages serve no nutritional value. In addition, empirical evidence shows no indication that such a tax would be regressive and unfairly penalize low income individuals and households. In a recent paper, Escobar et al. (2013) reviewed papers studied the effect of tax on SSB on obesity prevalence and its effectiveness in reducing the consumption and move it for more healthy substitutes. Nine articles were studied, six from USA and only one from France, Mexico and Brazil. Negative own price elasticity detected in all papers (pool own price elasticity equals -1.3). Indicating that 10% increase in the price of SSBs could result in about 13% reduction in its consumption. Studies showed also that, higher prices for SSBs were associated with an increased demand for alternative beverages such as fruit juice and milk and a reduced demand for diet drinks. Additionally, studies from USA revealed that a higher price could also lead to reduce the prevalence of overweight and obesity.

Recently Zhen et al., (2013) studied the effect of SSBs tax in United States using a censored Exact Affine Stone Index incomplete demand system for 23 packaged foods and beverages. Instrumental variables are used to control for endogenous prices. A half-cent per ounce increase in sugar-sweetened beverage prices is predicted to reduce total calories from the 23 foods and



beverages but increase sodium and fat intakes as a result of product substitution. The predicted decline in calories is larger for low-income households than for high-income households, although welfare loss is also higher for low-income households.

A main drawback of the mentioned articles is that it is mostly concentrate on the effect of intervention policies on a specific food group (e.g. Fruit and vegetable; SSB; fast food ... etc.) which shadow doubts on its reliability as it is omitting the income and the substitution effect and did not take into account the holistic nature of the diet. Gao et al. (2013) tried to fill this gap through applying household production theory to systematically estimate consumer demand for diet quality using the Healthy Eating Index (HEI). Their results indicated that, consumers have insufficient consumption of food containing dark green and orange vegetables, legumes and whole grains. Moreover, Age and education found to have a significant impact on consumer demand for diet quality. On the other hand, income does not have a significant effect on the demand for diet quality. They mentioned that own-price elasticities of demand for diet quality found to be inelastic. Simulation of tax scenarios revealed that a tax on SSB may be more efficient than a tax on fats, oils and salad dressing in improving consumer diet quality.

Combining the implementation of such a tax on SSBs and/or fats with targeted unsweetened beverages and/or fruit and vegetable subsidies, could have a higher positive effect on enhancing consumer's diet quality. Moreover, this combination offer a more politically viable option as it is expected to have a higher social acceptance and the revenue of the tax could be used in financing the subsidy without any extra burden on the public expenditure.

Another gap observed in the literature is the need to use advanced demand systems capable of taking into account the unobserved heterogeneity between individual which is especially important in the case of obesity. Those demand systems also should to be quite flexible allowing fitting the complexity and multi-dimensional nature of obesity. The recent developed Exact Affine Stone Index (EASI) could be considered more than appropriate in doing so. Zhen (2014) used EASI demand system in analyzing the effect of SSBs tax on obesity prevalence in United States.

Up to our knowledge no published article succeed in dealing with the two aforementioned shortcomings by using flexible demand systems such as EASI in analyzing the demand for diet



quality but in a framework taking into account the holistic nature of the diet. This could be an interesting future research line. We do so in this paper by estimating an EASI demand system to assess the Spanish consumers for diet quality taking into account the person BMI. This draws another novelty of our paper.

4. Exact Affine Stone Index (EASI) demand system

The Deaton and Muellbauer's (1980) Almost Ideal Demand System (AIDS) has been widely used due to its desirable characteristics. It is a plausible demand system, easy to estimate and the imposition of theoretical restrictions is straightforward.

In spite of its desirable characteristics, a main shortcoming of AIDS model is that the Engel curves are assumed to be linear in real expenditures. To avoid this problem and keeping the estimation process simple, we estimate an EASI demand system for the full diet of the Spanish consumers incorporating the weight status of the individual approximated by the Body Mass Index (BMI). The main advantage of EASI is the derivation of Implicit Marshallian demands which combine desirable features of both Hicksian and Marshallian demands. Similar to AIDS model, EASI budget shares are linear in parameters given real expenditures. However, EASI is superior in that the derived demands can have any rank and the Engel curves can have any shape over real expenditures. Moreover, EASI error terms can capture the unobserved preference heterogeneity among consumers.

Equation 1 can be rewritten following the cost function proposed by Lewbel and Pendakur (2009) which is particularly convenient for empirical estimation.

$$\ln C(p, y, z, \varepsilon) = y + \sum_{j=1}^J m^j(y, z) \ln p^j + \frac{1}{2} \sum_{j=1}^J \sum_{k=1}^J a^{jk}(z) \ln p^j \ln p^k + \frac{1}{2} \sum_{j=1}^J \sum_{k=1}^J b^{jk} \ln p^j \ln p^k y + \sum_{j=1}^J \varepsilon_j \ln p^j \quad (1)$$

Where y is the implicit utility function and corresponds to an affine function of the Stone index deflated by the log nominal expenditures, P is the price vector, z is a vector of demographic variables (includes BMI, age and gender) which proxy observable preference heterogeneity and ε a vector of error terms which include unobservable preferences heterogeneity.



The implicit Marshalian budget shares for each $j \in 1 \dots J$ is then given by:

$$w^j = \sum_{r=1}^R b_r^j y^r + \sum_{t=1}^T g_t^j z_t + \sum_{k=1}^J \sum_{t=1}^T a_{jkt} z_t \ln p^k + \sum_{k=1}^J b_{jk} \ln p^k y + \sum_{t=2}^T h_t^j z_t y + \varepsilon_j \quad (2)$$

Where y is defined as follows:

$$y = \frac{\ln x - \sum_{j=1}^J w_j \ln p^j + \frac{1}{2} \sum_{j=1}^J \sum_{k=1}^J a_{jkt} z_t \ln p^j \ln p^k}{1 - \frac{1}{2} \sum_{j=1}^J \sum_{k=1}^J b_{jk} \ln p^j \ln p^k} \quad (3)$$

Marshalian price, income and demographic elasticities are calculated following Lewbel and Pendakur (2009).

5. Data and empirical application

Data availability is the main limitation to carry out any economic analysis which relates obesity, food consumption and food prices. Currently, in Spain, there are two main sources of secondary data related with this issue. The first one is the National Health Survey (NHS). The NHS is a cross-section survey that provides ample data on the health status of citizens and its determinants. It is carried out by the National Institute of Statistics (INE) in cooperation with the Ministry of Health and Consumption. The survey collects information on the individual socioeconomic characteristics, morbidity, food habits and the demand for health care. Food habits refer to two main issues: type of breakfast and frequency of consumption of selected food groups. However, the data set does not provide information on quantities consumed (or purchased) neither on prices. The second main source that mainly refers to consumption data is the Spanish Household budget Survey. This survey provides annual information on the expenditure and quantity consumed of various classes of food products consumed by a stratified random sample of around 24,000 households. Since prices are not explicitly recorded, unit values for each group are calculated dividing expenditures by quantities. The survey also gathers



information on a limited number of household characteristics including the level of education and main activity of the head of the household, household income, household size, age and sex of family members and town size, among others. As similar characteristics are found in both data sets, our methodological approach has consisted of merging the two databases by defining different segments of population, using the socioeconomic characteristics of households. Then for each segment we calculated average values for the relevant variables contained in each database.

We made these segments using geographical variables (province and district size) and socio-demographic characteristics (age and gender). First, we divided each sample into 52 subsamples. Each subsample represented a province of the 52 Spanish provinces. Data for each province were divided into five segments of districts depending upon the district size. These five segments are: districts with more than 100,000 habitants; districts with 50,000 to 100,000 habitants; districts with 20,000 to 50,000 habitants; districts with 10,000 to 20,000 habitants; and districts with less than 10,000 habitants. After that, each subsample was divided using the socioeconomic characteristics (age and gender) of the family head. Age and gender were chosen since our analysis, in chapter 3 of this thesis, revealed that age and gender were found to be the most determinant factors of obesity prevalence. Using gender as a segmentation criterion, each subsample was divided into two subsamples: one included males family heads while the other one included female family heads. In the case of age, we created four groups: family head with less than 25 years; family head between 25 and 45 years; family head between 45 and 65 years; and family head older than 65 years. The cutoff points used to obtain the four age groups were determined based on the cut points (knots) obtained from our analysis in chapter 3. By doing so, we could get a set of about 2080 segments (52 provinces multiplied by 5 district size groups multiplied by 2 gender groups multiplied by 4 age groups). However, due to the absence of some segments in at least one of the original data sets, the final data set included 753 hypothetical representative average consumers.

For each segment, the constructed dataset provided micro data on expenditure, prices and the BMI together with some socio-demographic and economic characteristics such as age and gender. Food products were aggregated into the following eight food groups: Carbohydrates (includes grain and potatoes); Protein (includes meat, fish, egg and legumes); Dairy; Fat; Oils;



Fruits and Vegetables; Sweets; and other foods (includes food and nonalcoholic beverages not included in the previous groups). Unlike previous studies we separate oils from fat because most of the oils consumed in Spain are olive oil which is perceived as a very healthy product while other fats are perceived as unhealthy products.

Since prices are not explicitly recorded, unit values for each group are calculated dividing expenditures by quantities. Unit values may reflect not only spatial variations caused by supply shocks (i.e., transportation costs, cost of information, seasonal variations, etc.) but also differences in quality which can be attributed to brand loyalty or marketing services among other factors. Then, unit values were adjusted following Gao et al. (1997). The quality-adjusted price is defined as the difference between the unit price and the expected price, given its specific quality-related characteristics.

6. Results

Table 1 presents the descriptive statistics of the demographic variables, shares and prices of the eight food groups. It can be observed that protein and carbohydrates are the two biggest food groups with shares of around 38% and 17%, respectively, of the total food expenditure. On the other hand fat and oil are the two smallest food groups with shares of only 0.22% and 2.6%, respectively. The lowest average price was observed for the dairy group (1.67 euro) while the highest price corresponded to other foods group (10.86 euro).

[Insert table 1 here]

Then, the EASI model given in (2) was estimated using BMI, age and gender as demographic variables¹. The system is estimated by an iterated 3SLS. This estimator is similar to the estimator suggested by Blundell and Robin (1999) for the QUAIDS.

The most important economic information in demand systems is provided by elasticities. Expenditure, price and demographic elasticities were calculated following Lewbel and Pendakur (2009). The estimated conditional (as we assumed weak separability) expenditure, own-price and

¹ Estimation results are presented in annex1.



demographic (BMI, age and gender) elasticities are presented in table 2. As can be observed, all expenditure elasticities are positive and statistically significant (except for fat and other foods). Sweets (1.26), oil (1.15) and fat (1.12) are considered luxury products. The elasticities of fruit and vegetables, protein and other foods groups were found to be not significantly different from 1; while carbohydrates (0.92) and dairy (0.91) can be defined as necessity.

[Insert table 2 here]

All own-price elasticities are negative and inelastic except in the case of dairy (-1.01) and fat (-1.05). The food groups with the most inelastic demand are oil (-0.20) and carbohydrate (-0.33). This could be explained by the fact that Spanish consumers have strong positive preferences for olive oil and bread which represent the main food products in oil and carbohydrates groups. This inelastic price elasticity is consistent with the nature of food products and that Spanish consumer, as all developed countries; spend a small share of their income on food.

Most demographic elasticities are statistically non-significant and with a quite small magnitude. Increasing the age, increases slightly the consumption of protein and fruits and vegetables while decreases the consumption of carbohydrates and sweets. This emphasized that the elder are consuming healthier diet may be due to that they are watching more their diets to avoid health consequences which is more observed among old people. In respect to gender being a male increases the consumption of protein while decreases consumption of sweets. The BMI has a small positive effect on oil consumption and on the other hand it decreases the consumption of healthy foods such as fruit and vegetable.

After estimating the parameters and calculating the elasticities, we simulated price change scenarios by modifying the level of indirect taxes (Value Added Tax (VAT)). In Spain, VAT is set at 21% for most products. However, necessities like bread, flour, eggs, milk, fruits and vegetables, legumes, potatoes and grains are taxed at 4%, while for the rest of food products the VAT is 10%. Different price scenarios were simulated: 1) Decreasing taxes on healthy products such as Fruits and Vegetables (from 4% to 1%); 2) Increasing taxes on sugary unhealthy products such as sweets (from 10% to 21%); 3) increasing taxes on fats (from 10% to 21%); 4) increasing taxes on both sugary and fatty products as fat and sweets at the same time (from 10% to 21%); 5) decreasing taxes on fruits and vegetables (from 4% to 1%) and increase taxes on fat



(from 10% to 21%) at the same time; 6) decreasing taxes on fruits and vegetables (from 4% to 1%) and increase taxes on sweets (from 10% to 21%) at the same time; 7) decreasing taxes on fruits and vegetables (from 4% to 1%) and increase taxes on both fat and sweets (from 10% to 21%) at the same time. In all scenarios, we assumed that the food supply is competitive and that there are not specialized inputs (i.e. marginal and average costs remain constant). Under these assumptions, any price change will be fully passed forward to consumers. Own- and cross-price elasticities were used to make the simulations assuming that total food expenditures remain constant.

Results of the different simulation scenarios are presented in table 3. It worth mentioning that, in the case of sole intervention policies, the smallest effect observed in the case of subsidizing fruit and vegetable. Even a tax on fat or fat and sweets could resulted in a higher consumption of fruit and vegetable than the increase obtained through subsidizing fruit and vegetable, due to substitution effect. Generally a tax on fat has a higher impact, in motivating healthy consumption, than similar tax on sweets. Fat tax has an unintended effect on protein consumption. Although mixed intervention policies has a quite similar effect to taxing unhealthy products (e.g. fat; sweets), these mixed intervention policies could have higher social acceptability.

[Insert table 3 here]

7. Concluding remarks

This paper is one of the first attempts to analyze how food price intervention policies can improve diet quality and combat obesity prevalence in Spain. We attain this objective through merging two data sets which were initially designed to collect information for different purposes. The methodological approach followed here consisted in the specification and estimation of an EASI demand system from which expenditure; price and demographic variables including BMI elasticities were calculated. Our results indicate that changes in the BMI have a quite small positive (negative) effect on oil (fruit and vegetable) consumption in Spain. Taxing unhealthy products (e.g. fat and sweets) found to have higher impact on food consumption than subsidizing



healthy foods (e.g. fruit and vegetable). Mixed intervention policies could have a higher social acceptance. Further research is needed in order to calculate the effect of changes in calorie consumption and consequently on BMI. Examining experimentally the social acceptance of the different price intervention policies is considered as an interesting future research line.

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Table 1. Structure of food expenditure in Spain by socio-economic groups (2006)

Variable	Mean	St. Deviation	Min.	Max
Age	48	18.81	18	84
Gender	0.6	0.48	0	1
BMI	26.02	2.39	18.22	36.13
Share (carbohydrate)	16.81	3.79	3.95	46.55
Share (Protein)	38.04	5.98	8.16	56.74
Share (dairy)	13.27	3.06	4.05	25.39
Share (fat)	0.22	0.24	0	2.23
Share (oil)	2.6	1.75	3.91	29.23
Share (fruit and vegetables)	13.84	3.23	1.99	31.98
Share (sweets)	8.48	3.08	1.67	23.29
Share (other food)	6.75	2.33	18.22	36.13
Price (carbohydrate)	2.27	0.41	0.17	3.64
Price (Protein)	7.04	1.14	1.61	11.35
Price (dairy)	1.67	0.34	0.79	3.5
Price (fat)	2.39	0.5	0.53	5.37
Price (oil)	9.73	29.96	0.86	49.47
Price (fruit and vegetables)	1.59	0.28	0.52	2.68
Price (sweets)	1.75	0.61	0.63	5.79
Price (other food)	10.86	5.78	2.93	50.98

Source: Encuesta Continua de Presupuestos Familiares (INE) and own elaboration

Table 2. Calculated own-price, expenditure and demographic elasticity

Marshallian own-price elasticity	
Carbohydrate	-0.33 (0.02)
Protein	-0.45 (0.04)
Dairy	-1.01 (0.02)
Fat	-1.05 (0.00)
Oil	-0.20 (0.01)
Fruit and Vegetables	-0.87 (0.02)
Sweets	-0.79 (0.01)
Other	-0.76 (0.51)
Expenditure elasticity	
Carbohydrate	0.92 (0.09)
Protein	1.00 (0.07)
Dairy	0.91 (0.11)
Fat	1.12 (0.72)
Oil	1.15 (0.36)
Fruit and Vegetables	0.97 (0.11)
Sweets	1.26 (0.16)
Other	1.01 (0.61)
Demographic elasticity	
BMI	
Carbohydrate	0.0009(0.0009)

Protein	-0.0009 (0.001)
Dairy	0.000 (0.0008)
Fat	-0.000 (0.000)
Oil	0.001 (0.000)
Fruit and Vegetables	-0.002 (0.0007)
Sweets	0.0004 (0.0007)
Other	0.000 (0.0022)
Age	
Carbohydrate	-0.0003(0.0001)
Protein	0.0008 (0.0002)
Dairy	-0.0001 (0.0001)
Fat	0.000 (0.0000)
Oil	0.000 (0.000)
Fruit and Vegetables	0.0007 (0.0001)
Sweets	-0.0007 (0.0001)
Other	-0.000 (0.0003)
Gender	
Carbohydrate	0.003 (0.003)
Protein	0.019 (0.005)
Dairy	-0.001 (0.0032)
Fat	-0.000 (0.000)
Oil	-0.000(0.000)
Fruit and Vegetables	-0.005 (0.0030)



Sweets	-0.006 (0.0027)
Other	-0.000 (0.0086)

Note: Standard Error in parentheses

Table 3. Impact of price intervention policies on quantities consumed

Food Groups		Subsidizing healthy foods	Taxing unhealthy foods			Mixed intervention policies		
		Fruit and Vegetable	Sweets	Fat	Sweet and Fat	Fruit and Vegetable + Sweet	Fruit and Vegetable + Fat	Fruit and Vegetable + Sweet and Fat
Change in the quantity of	Carbohydrate	0.24	-2.61	-6.60	-9.21	-6.36	-2.38	-8.98
	Protein	0.53	-3.81	-19.91	-23.72	-19.38	-3.28	-23.19
	Dairy	-0.34	0.78	6.52	7.30	6.18	0.43	6.96
	Fat	-0.03	0.21	-10.54	-10.33	-10.56	0.19	-10.35
	Oil	0.07	-1.21	2.63	1.41	2.69	-1.15	1.48
	Fruit and Vegetables	2.60	2.19	5.41	7.60	8.01	4.79	10.20
	Sweets	-0.48	-7.89	8.27	0.39	7.80	-8.36	-0.09
	Other	0.33	-0.35	3.08	2.74	3.42	-0.02	3.07

Annex 1. Estimates of the EASI demand system

Equations and variables	Estimate	Std. Error	t value	Pr(> t)
eq1_Constante	0.1576	0.0164	9.58	0
eq1_y^1	0.1121	0.0633	1.77	0.0769
eq1_y^2	-0.069	0.0369	-1.87	0.0618
eq1_y^3	-0.0906	0.0818	-1.11	0.268
eq1_y^4	0.2779	0.1129	2.46	0.0139
eq1_y^5	0.278	0.1524	1.82	0.0682
eq1_age	-0.0003	0.0001	-3.56	0.0004
eq1_gender	0.0033	0.0028	1.17	0.2439
eq1_BMI	0.001	0.0007	1.33	0.1826
eq1_y*age	0	0.0003	-0.15	0.8812
eq1_y*gender	0.0191	0.0104	1.83	0.0675
eq1_y*BMI	-0.0048	0.0028	-1.7	0.0884
eq1_pCarbohydrate	0.1228	0.0415	2.96	0.0031
eq1_pProtein	-0.0889	0.0424	-2.09	0.0363
eq1_pDairy	0.0305	0.028	1.09	0.2763
eq1_pFat	0.0022	0.0033	0.64	0.5196
eq1_pOil	-0.0173	0.0187	-0.92	0.3564
eq1_pFV	-0.0212	0.0287	-0.74	0.4592
eq1_pSweet	-0.0092	0.0212	-0.43	0.6652
eq1_y*pCarbohydrate	-0.1966	0.0375	-5.24	0

eq1_y*pProtein	0.2222	0.0446	4.99	0
eq1_y*pDairy	-0.0485	0.028	-1.74	0.0825
eq1_y*pFat	0.0044	0.0031	1.41	0.1599
eq1_y*pOil	0.0004	0.0179	0.02	0.9828
eq1_y*pFV	0.0228	0.0284	0.8	0.4226
eq1_y*pSweet	-0.0066	0.0224	-0.29	0.77
eq1_age*pCarbohydrate	-0.0002	0.0008	-0.32	0.7482
eq1_age*pProtein	0	0.0008	0.02	0.9805
eq1_age*pDairy	-0.0002	0.0005	-0.43	0.6685
eq1_age*pFat	-0.0001	0.0001	-1.17	0.2435
eq1_age*pOil	-0.0002	0.0004	-0.52	0.6011
eq1_age*pFV	0.0002	0.0005	0.37	0.7084
eq1_age*pSweet	-0.0002	0.0004	-0.48	0.6327
eq2_Constante	0.3534	0.0251	14.08	0
eq2_y^1	-0.1192	0.0972	-1.23	0.2203
eq2_y^2	0.0086	0.0596	0.14	0.8858
eq2_y^3	-0.1006	0.1264	-0.8	0.4263
eq2_y^4	-0.0388	0.1992	-0.19	0.8458
eq2_y^5	0.1705	0.2582	0.66	0.509
eq2_age	0.0008	0.0001	6.05	0
eq2_gender	0.0185	0.0043	4.32	0
eq2_BMI	-0.0009	0.0011	-0.83	0.4074
eq2_y*age	-0.0003	0.0005	-0.64	0.5195

eq2_y*gender	-0.0357	0.016	-2.24	0.0253
eq2_y*BMI	0.0064	0.0043	1.48	0.1397
eq2_pCarbohydrate	-0.0889	0.0424	-2.09	0.0363
eq2_pProtein	0.2589	0.0787	3.29	0.001
eq2_pDairy	-0.0228	0.0408	-0.56	0.5769
eq2_pFat	-0.0139	0.0044	-3.16	0.0016
eq2_pOil	-0.0432	0.0252	-1.71	0.087
eq2_pFV	-0.0295	0.04	-0.74	0.4597
eq2_pSweet	-0.0652	0.0302	-2.16	0.0311
eq2_y*pCarbohydrate	0.2222	0.0446	4.99	0
eq2_y*pProtein	-0.3367	0.1035	-3.25	0.0012
eq2_y*pDairy	0.0137	0.0539	0.25	0.7994
eq2_y*pFat	0.0095	0.0064	1.49	0.1374
eq2_y*pOil	0.001	0.0351	0.03	0.9778
eq2_y*pFV	0.0001	0.0556	0	0.9982
eq2_y*pSweet	0.0467	0.0415	1.13	0.2599
eq2_age*pCarbohydrate	0	0.0008	0.02	0.9805
eq2_age*pProtein	-0.001	0.0014	-0.72	0.4745
eq2_age*pDairy	-0.0006	0.0008	-0.81	0.4202
eq2_age*pFat	0.0002	0.0001	2.43	0.0153
eq2_age*pOil	0.001	0.0005	2.21	0.0273
eq2_age*pFV	0.0001	0.0007	0.1	0.9208
eq2_age*pSweet	0.0009	0.0006	1.52	0.1288

eq3_Constante	0.133	0.0147	9.04	0
eq3_y^1	-0.0161	0.0571	-0.28	0.7775
eq3_y^2	-0.1059	0.0344	-3.08	0.0021
eq3_y^3	0.0458	0.0743	0.62	0.5372
eq3_y^4	0.2215	0.1127	1.96	0.0495
eq3_y^5	0.0444	0.1481	0.3	0.7642
eq3_age	-0.0002	0.0001	-2.05	0.0407
eq3_gender	-0.0016	0.0025	-0.63	0.5268
eq3_BMI	0.0005	0.0007	0.8	0.4264
eq3_y*age	0.0003	0.0003	0.88	0.3815
eq3_y*gender	0.0065	0.0094	0.7	0.4855
eq3_y*BMI	-0.0007	0.0025	-0.27	0.7856
eq3_pCarbohydrate	0.0305	0.028	1.09	0.2763
eq3_pProtein	-0.0228	0.0408	-0.56	0.5769
eq3_pDairy	-0.0534	0.0371	-1.44	0.1507
eq3_pFat	0.0023	0.0034	0.69	0.4927
eq3_pOil	0.035	0.0182	1.93	0.054
eq3_pFV	0.039	0.0279	1.4	0.162
eq3_pSweet	-0.0219	0.0195	-1.13	0.2601
eq3_y*pCarbohydrate	-0.0485	0.028	-1.74	0.0825
eq3_y*pProtein	0.0137	0.0539	0.25	0.7994
eq3_y*pDairy	0.0617	0.0488	1.26	0.2063
eq3_y*pFat	-0.0065	0.0045	-1.43	0.1536

eq3_y*pOil	-0.0242	0.0243	-1	0.3182
eq3_y*pFV	0.0453	0.0367	1.24	0.2164
eq3_y*pSweet	-0.0241	0.0271	-0.89	0.3745
eq3_age*pCarbohydrate	-0.0002	0.0005	-0.43	0.6685
eq3_age*pProtein	-0.0006	0.0008	-0.81	0.4202
eq3_age*pDairy	0.001	0.0007	1.5	0.1331
eq3_age*pFat	0	0.0001	-0.28	0.7832
eq3_age*pOil	-0.0006	0.0003	-1.72	0.0853
eq3_age*pFV	-0.0005	0.0005	-0.93	0.3534
eq3_age*pSweet	0.0006	0.0004	1.76	0.0779
eq4_Constante	0.0009	0.0014	0.63	0.529
eq4_y^1	0.0064	0.0053	1.22	0.2208
eq4_y^2	0.0007	0.0033	0.2	0.8415
eq4_y^3	-0.002	0.0069	-0.28	0.7766
eq4_y^4	0.0052	0.0111	0.47	0.6399
eq4_y^5	0.0054	0.0141	0.38	0.701
eq4_age	0	0	0.99	0.3206
eq4_gender	-0.0009	0.0002	-3.73	0.0002
eq4_BMI	0.0001	0.0001	0.93	0.3545
eq4_y*age	0	0	0.63	0.5259
eq4_y*gender	0.0009	0.0009	1.01	0.3121
eq4_y*BMI	-0.0003	0.0002	-1.21	0.227
eq4_pCarbohydrate	0.0022	0.0033	0.64	0.5196

eq4_pProtein	-0.0139	0.0044	-3.16	0.0016
eq4_pDairy	0.0023	0.0034	0.69	0.4927
eq4_pFat	-0.0021	0.001	-2.13	0.0333
eq4_pOil	0.0006	0.0027	0.23	0.8162
eq4_pFV	0.007	0.0037	1.88	0.0595
eq4_pSweet	0.004	0.0022	1.78	0.0756
eq4_y*pCarbohydrate	0.0044	0.0031	1.41	0.1599
eq4_y*pProtein	0.0095	0.0064	1.49	0.1374
eq4_y*pDairy	-0.0065	0.0045	-1.43	0.1536
eq4_y*pFat	-0.0038	0.0018	-2.17	0.0304
eq4_y*pOil	-0.0033	0.0037	-0.89	0.3762
eq4_y*pFV	-0.0005	0.0051	-0.09	0.9276
eq4_y*pSweet	0.0019	0.0032	0.6	0.5513
eq4_age*pCarbohydrate	-0.0001	0.0001	-1.17	0.2435
eq4_age*pProtein	0.0002	0.0001	2.43	0.0153
eq4_age*pDairy	0	0.0001	-0.28	0.7832
eq4_age*pFat	0	0	1.97	0.0488
eq4_age*pOil	0	0.0001	-0.02	0.9877
eq4_age*pFV	-0.0001	0.0001	-1.68	0.0936
eq4_age*pSweet	0	0	-1.02	0.3072
eq5_Constante	-0.0038	0.0086	-0.44	0.6605
eq5_y^1	-0.025	0.0332	-0.75	0.4528
eq5_y^2	0.036	0.0203	1.77	0.0764

eq5_y^3	0.0145	0.0434	0.34	0.7373
eq5_y^4	-0.1093	0.0681	-1.61	0.1085
eq5_y^5	-0.1171	0.0866	-1.35	0.1763
eq5_age	0.0001	0	1.19	0.2322
eq5_gender	-0.0033	0.0015	-2.25	0.0243
eq5_BMI	0.001	0.0004	2.69	0.0072
eq5_y*age	0	0.0002	-0.09	0.9317
eq5_y*gender	0.0001	0.0055	0.02	0.9879
eq5_y*BMI	0.0012	0.0015	0.83	0.4088
eq5_pCarbohydrate	-0.0173	0.0187	-0.92	0.3564
eq5_pProtein	-0.0432	0.0252	-1.71	0.087
eq5_pDairy	0.035	0.0182	1.93	0.054
eq5_pFat	0.0006	0.0027	0.23	0.8162
eq5_pOil	0.0187	0.0185	1.01	0.3115
eq5_pFV	0.0184	0.0193	0.96	0.3394
eq5_pSweet	-0.025	0.0127	-1.97	0.0493
eq5_y*pCarbohydrate	0.0004	0.0179	0.02	0.9828
eq5_y*pProtein	0.001	0.0351	0.03	0.9778
eq5_y*pDairy	-0.0242	0.0243	-1	0.3182
eq5_y*pFat	-0.0033	0.0037	-0.89	0.3762
eq5_y*pOil	0.0328	0.0251	1.31	0.1914
eq5_y*pFV	-0.0517	0.0261	-1.98	0.0473
eq5_y*pSweet	0.009	0.0179	0.5	0.6145

eq5_age*pCarbohydrate	-0.0002	0.0004	-0.52	0.6011
eq5_age*pProtein	0.001	0.0005	2.21	0.0273
eq5_age*pDairy	-0.0006	0.0003	-1.72	0.0853
eq5_age*pFat	0	0.0001	-0.02	0.9877
eq5_age*pOil	0	0.0004	0.12	0.9043
eq5_age*pFV	-0.0004	0.0004	-1.21	0.2271
eq5_age*pSweet	0.0003	0.0002	1.3	0.1945
eq6_Constante	0.1595	0.014	11.36	0
eq6_y^1	0.0126	0.0544	0.23	0.817
eq6_y^2	0.0592	0.033	1.8	0.0727
eq6_y^3	0.1562	0.0704	2.22	0.0266
eq6_y^4	-0.1862	0.1078	-1.73	0.0842
eq6_y^5	-0.3091	0.1399	-2.21	0.0272
eq6_age	0.0008	0.0001	10.04	0
eq6_gender	-0.006	0.0024	-2.48	0.0132
eq6_BMI	-0.0021	0.0006	-3.38	0.0007
eq6_y*age	-0.0001	0.0003	-0.31	0.7549
eq6_y*gender	0.0018	0.0089	0.21	0.8374
eq6_y*BMI	-0.0012	0.0024	-0.51	0.6108
eq6_pCarbohydrate	-0.0212	0.0287	-0.74	0.4592
eq6_pProtein	-0.0295	0.04	-0.74	0.4597
eq6_pDairy	0.039	0.0279	1.4	0.162
eq6_pFat	0.007	0.0037	1.88	0.0595

eq6_pOil	0.0184	0.0193	0.96	0.3394
eq6_pFV	-0.0365	0.0402	-0.91	0.3644
eq6_pSweet	0.0443	0.02	2.22	0.0264
eq6_y*pCarbohydrate	0.0228	0.0284	0.8	0.4226
eq6_y*pProtein	0.0001	0.0556	0	0.9982
eq6_y*pDairy	0.0453	0.0367	1.24	0.2164
eq6_y*pFat	-0.0005	0.0051	-0.09	0.9276
eq6_y*pOil	-0.0517	0.0261	-1.98	0.0473
eq6_y*pFV	-0.0482	0.055	-0.88	0.3809
eq6_y*pSweet	0.0141	0.0282	0.5	0.6169
eq6_age*pCarbohydrate	0.0002	0.0005	0.37	0.7084
eq6_age*pProtein	0.0001	0.0007	0.1	0.9208
eq6_age*pDairy	-0.0005	0.0005	-0.93	0.3534
eq6_age*pFat	-0.0001	0.0001	-1.68	0.0936
eq6_age*pOil	-0.0004	0.0004	-1.21	0.2271
eq6_age*pFV	0.0011	0.0008	1.47	0.1422
eq6_age*pSweet	-0.0005	0.0004	-1.22	0.2208
eq7_Constante	0.1135	0.0128	8.84	0
eq7_y^1	0.0089	0.0497	0.18	0.8579
eq7_y^2	0.0372	0.0303	1.23	0.2185
eq7_y^3	0.0082	0.0636	0.13	0.8977
eq7_y^4	-0.0877	0.0973	-0.9	0.3671
eq7_y^5	-0.0824	0.1246	-0.66	0.5081

eq7_age	-0.0008	0.0001	-11.12	0
eq7_gender	-0.0063	0.0022	-2.89	0.0038
eq7_BMI	0.0004	0.0006	0.72	0.4693
eq7_y*age	0	0.0003	-0.11	0.9112
eq7_y*gender	-0.0069	0.0081	-0.85	0.3941
eq7_y*BMI	0.0008	0.0022	0.35	0.7229
eq7_pCarbohydrate	-0.0092	0.0212	-0.43	0.6652
eq7_pProtein	-0.0652	0.0302	-2.16	0.0311
eq7_pDairy	-0.0219	0.0195	-1.13	0.2601
eq7_pFat	0.004	0.0022	1.78	0.0756
eq7_pOil	-0.025	0.0127	-1.97	0.0493
eq7_pFV	0.0443	0.02	2.22	0.0264
eq7_pSweet	0.0823	0.0211	3.9	0.0001
eq7_y*pCarbohydrate	-0.0066	0.0224	-0.29	0.77
eq7_y*pProtein	0.0467	0.0415	1.13	0.2599
eq7_y*pDairy	-0.0241	0.0271	-0.89	0.3745
eq7_y*pFat	0.0019	0.0032	0.6	0.5513
eq7_y*pOil	0.009	0.0179	0.5	0.6145
eq7_y*pFV	0.0141	0.0282	0.5	0.6169
eq7_y*pSweet	-0.015	0.0298	-0.5	0.6154
eq7_age*pCarbohydrate	-0.0002	0.0004	-0.48	0.6327
eq7_age*pProtein	0.0009	0.0006	1.52	0.1288
eq7_age*pDairy	0.0006	0.0004	1.76	0.0779



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eq7_age*pFat	0	0	-1.02	0.3072
eq7_age*pOil	0.0003	0.0002	1.3	0.1945
eq7_age*pFV	-0.0005	0.0004	-1.22	0.2208
eq7_age*pSweet	-0.0013	0.0004	-3.2	0.0014