How do consumers respond to "sin taxes"? New evidence from a tax on sugary drinks

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ABSTRACT

It is unclear what the effects of taxes on sugar sweetened beverages (SSBs) are on consumer behaviour and which consumers may be affected the most. We evaluate the effect of the SSB tax introduced in Catalonia (but not in the rest of Spain) in May 2017 using loyalty card data of monthly purchases by 884,843 households from May 2016 to April 2018. Using a Difference-in-Differences approach, we study the SSB tax effect on the purchased quantity of beverages and sugar. Our results suggest a reduction in purchases of taxed beverages and a small increase in purchases of untaxed beverages. Households have substituted taxed beverages with their lower sugar (untaxed) counterparts. This has led to a 2.2% overall reduction in sugar purchases from beverages. Our study implies that although sin taxes moderately change consumer behaviour, a combination of different policies would be required to tackle obesity.

1. Introduction

The World Health Organization (WHO) considers the rise of obesity and non-communicable diseases (NCDs) as a major public health concern (World Health Organization, 2015). In the OECD countries, about 19.5 percent of the population aged 15 or over are obese (OECD, 2017). In countries like the United Kingdom and the United States this proportion reaches 26.9 and 38.2 percent, respectively, while in Spain it reaches 16.7 percent (OECD, 2017). Unhealthy diet, physical inactivity, smoking and alcohol use are recognised to be the most significant risk factors for this growing NCDs prevalence (World Health Organization, 2010). Sugars added to food and beverages are thought to contribute to weight gain and obesity (Malik et al., 2006; Johnson et al., 2007), to high glycaemic levels which may lead to type 2 diabetes (Malik & Hu, 2011, 2012) and to higher overall calorie intake (Johnson et al., 2009).

A wide range of policies have been introduced to alter food and beverage choices such as regulation of fast food outlets (Sturm and Cohen, 2009), or products at check-out (Horsley et al., 2014); labelling of food products (Fichera and von Hinke, 2020; Allais et al., 2015; Heike and Taylor, 2013); restriction of junk food advertising (Ippolito & Mathios, 1990, 1995; Chou et al., 2008); and "sin" taxes on specific goods such as alcohol or sugar-sweetened beverages (SSBs). SSB taxes have been introduced in many countries (Cornelsen and Smith, 2018; Cawley et al., 2019a, 2019b). Most of the literature finds positive effects of SSB taxes on health-related outcomes (Barrientos-Gutierrez, 2017; Basto-Abreu, 2019; Grummon and Lockwood, 2019; Lal and Mantilla-Herrera, 2017; Veerman and Sacks, 2016), although one study reports mixed evidence (Grogger, 2017). The majority of studies report reductions in purchases and sales (Cawley et al., 2019a, 2019b; Roberto et al., 2019; Falbe et al., 2016; Silver et al., 2017). These results are confirmed by recent meta-analyses which also find that tiered taxes and volumetric taxes (per litre) are related to greater declines in taxed beverage consumption than *ad valorem* taxes (Teng et al., 2019; Escobar et al., 2013). Reductions in consumption vary across locations and taxed beverages, some impacting untaxed beverages. However, the effectiveness of fiscal policies for food and beverage consumption depends on their salience (Chetty et al., 2009) and on their pass-through, the WHO suggests a 20% increase in retail price would result in proportional reductions in consumption of sugary drinks (World Health Organization, 2015). The effect of these taxes also depends on how consumers respond (e.g. whether they switch to other unhealthy products, see for instance Nakhimovsky et al., 2016; Caro et al., 2017), and which consumers respond (e.g. depending on their socio-economic status, see for instance Redondo et al., 2018; Nakamura et al., 2018).

The aim of this paper is to investigate the effect of the Catalonian SSB tax on the purchased quantity of beverages and sugar. The tax was introduced on the May 1, 2017 in a region of Spain, Catalonia, but not in the rest of Spain. It has a tiered structure where beverages are taxed according to their sugar content. We examine how this effect varies by socio-demographic characteristics. Using loyalty card data of monthly purchases by 884,843 households from May 2016 to April 2018, we also explore potential mechanisms driving our results.

We make several contributions to the literature on SSBs taxes. Firstly, we evaluate a new sugar tax implemented in Catalonia using product-level data and a geographic control group over a period of two years.

Secondly, most of the U.S. studies are based on flat taxes (see review by Cawley et al., 2019a, 2019b), instead, we focus on a two-tier tax, like the one recently implemented in the United Kingdom, in the Republic of Ireland and in Catalonia (Vall Castello and Lopez-Casasnovas, 2020; Royo-Bordonada et al., 2019; Puig-Codina et al., 2020). A recent study examines a multiple tier tax in Chile exploiting the before and after variation in purchases across the country (Nakamura et al., 2018). The two-tier Catalonia tax charges 0.08€ per litre to beverages containing between 5 and 8 g per 100 ml, and 0.12€ per litre to beverages containing more than 8 g per 100 ml.

Thirdly, like few emerging studies evaluating the effects of SSBs taxes (Cawley et al., 2019a, 2019b; Falbe et al., 2016; Rojas and Wang, 2020), we use a control group of stores in a similar geographical area to Catalonia (i.e. the rest of Spain) and study how the tax affects consumer behaviour, with a rich database of individual purchases in a large supermarket chain. However, unlike these studies that focus on city-level taxes using primary survey data (with the exception of Rojas and Wang (2020)), we use loyalty card data. The impact of the Catalonia tax on sales has been investigated by (Vall Castello and Lopez-Casasnovas, 2020). Using aggregate data on 71 beverages from a supermarket chain in Catalonia and a before and after methodology, they find a 7.7% reduction in SSB purchases. This reduction is stronger in areas with higher income households. However, they do not have a control group outside Catalonia. A further study of young people in relatively poorer districts in Barcelona and Madrid has investigated the impact of the tax on SSB consumption (Royo-Bordonada et al., 2019). Using data collected from 1929 young people and a difference in differences methodology, they find a 39% reduction in consumption of taxed beverages in Barcelona compared to Madrid. Although this study has a control group outside Catalonia, it focuses on a specific population with limited sample, individual and product characteristics.

Fourthly, in order to understand the broad effect of the SSB tax, our contribution is to focus on the whole beverage budget as there may be substitution, complementarity or budget effects towards untaxed beverages. Whilst the above-mentioned studies do examine taxed and untaxed beverages, they do not include all beverages. Also, the relatively highly aggregated beverage categories used by Cawley et al. (2019a, 2019b), Falbe, et al. (2016) and Rojas and Wang (2020) may hide important *within* beverage categories heterogeneities.

Finally, we are able to investigate how our results vary by socio-demographic characteristics, e.g. which consumers change their decisions depending on their socio-economic status, age and family composition (previously investigated by Cawley et al. (2019a, 2019b) on a more aggregated set of beverage categories).

Our identification strategy is based on Difference-in-Differences (DiD) models and it exploits three features. First, we exploit the time introduction of the policy and account for potential anticipation effects. Second, we use the fact that the tax was applied to some beverages in Catalonia, an autonomous community located in the North-eastern Iberian Peninsula, but not in the rest of Spain. Third, we consider only *within*-spell changes in quantities and sugar bought, where the spell is any household-store combination, to account for any fixed household-store characteristics. Our identification assumption is that beverage purchases in Catalonia and the rest of Spain follow the same trend before the introduction of the tax, which we test for in a pre-trend analysis. As

we consider both taxed and untaxed beverages, we are able to examine how households substitute across beverages in response to the tax. Many studies of SSB taxes have used a DiD approach, but some evaluations of these taxes have lacked a control group. Some studies have used untaxed beverages as control group ignoring potential spillovers (Vall Castello and Lopez-Casasnovas, 2020; Colchero et al., 2016a, 2016b), some others have used either nearby (Cawley at al., 2018a, 2018b; Rojas and Wang, 2020; Silver et al., 2017) or distant (Falbe et al., 2016; Zhong et al., 2018; Bollinger and Sexton, 2018) geographical areas. As noted by Cawley et al. (2019a, 2019b), there are advantages and disadvantages in each approach. Compared to these studies, our identification strategy focuses on a large nearby geographical area and we directly test whether our estimates are biased by cross-border shopping.

2. The new tax regulatory framework

On the March 28, 2017 the regional parliament of Catalonia approved a fiscal law containing the SSB tax (Diari Oficial de la Generalitat de Catalunya, 2017: No. 5/7340). This tax came into place on the May 1, 2017.

Article 72 of the fiscal law defines taxable SSBs as "*those beverages that include caloric sweeteners such as sugar, honey, fructose, sucrose, syrups or nectar (corn, maple, agave and rice)*". It also provides a detailed list of taxable products: (i) soft drinks or colas without alcohol, with flavours, with or without gas, commercially prepared that are sold in bottles or cans as well as those on draught; (ii) beverages of nectar and juices from fruits; (iii) sport drinks designed for athletes to rehydrate and to rest the electrolytes, sugar and other nutrients; (iv) tea and coffee beverages; (v) energetic drinks (i.e. carbonated beverages that contain large amounts of caffeine, sugar and other ingredients such as vitamins, amino acids and herbal stimulants); (vi) sweetened milk, milkshakes and combinations of milk and sugared fruit juice; (vii) veggie beverages; and (viii) waters with flavours. Untaxed products include: (i) beverages made from natural, concentrated or reconstructed fruit or vegetable juices; (ii) milks or milks derivatives that do not contain additional caloric sweeteners; (iii) yeast yoghurts, drinkable fermented milk; (iv) medical products, and (v) alcoholic beverages.

The law established that the tax was to be paid by the legal entity (in our case, retailers) providing the beverage to the consumer. From the legally defined generic list of taxable beverages, retailers were able to decide which specific beverages were to be taxed.

The structure of the levy is as follows: (a) 0.08€ per litre on beverages containing between 5 and 8 g per 100 ml, and (b) 0.12€ per litre on beverages containing more than 8 g per 100 ml. This levy resembles the U.K. Soft Drink Industry Levy which came into place on the April 6, 2018 (HM Revenues and Customs, 2017), but was already designed and released by 2017.

3. Data and descriptive statistics

Our dataset consists of all beverage purchases made by loyalty card holders in a specific supermarket chain from May 2016 to April 2018, one year before and one year after the tax policy. This is a middle range chain representing 6% of all store chains' market share in Catalonia. Although it is located in Catalonia, the chain owns and manages some supermarkets in other regions of Spain, included in our database. An observation is denoted by each item purchased in a shopping trip. In order to ensure spell comparability, we exclude stores that opened or closed within our period of interest. We then create a dataset of all household purchases and drop those made by organisations, and online purchases. We identify organisational purchases as those made by cardholders who spend more than 2000 euros in one shopping trip, or buy in more than six different stores within a single month, or buy more than 100 units of a single product. These represent only about 0.002% of the total number of observations.

The advantages of these data are that they are longitudinal, and they

contain very detailed information on each beverage. We have information on the item bought, the date of purchase, the quantity (in litres) purchased, prices, beverage and non-beverage expenditure on each shopping trip. Taxed beverages were then invoiced as "IBEE" (Impost de Begudes Ensucrades Envasades) and authorities were communicated the total amount collected from IBEE every month. Our loyalty card data contains information about which beverages were invoiced as IBEE. Like the Kantar WorldPanel data used by Nakamura et al. (2018), our data does not contain nutritional information for beverages. Therefore, we complement our data with information on the sugar content (in grams per 100 ml) of all beverages collected from the webpages of multiple supermarket chains. As this information was collected in 2017, we cannot observe changes in the sugar content of beverages.

The data also provide some demographic characteristics of the card holder and the location of the store. We have the card holder's demographic characteristics such as age and gender; a dummy variable that equals one if s/he has children between the age of 0–3 and another one indicating whether s/he has children between the age of 3 and 15; an indicator of customer's loyalty to the chain (referring to the past three purchases, it indicates whether the customer always shops at the chain, whether s/he shops at other chains or sporadically shops at the chain). We use two measures of socio-economic position. The first one is based on the store postcodes. We have matched the main database with microdata corresponding to a random sample of declarants of the 2013 income tax, provided by the Fiscal Studies Institute (2013). It contains 1112 postcodes for Catalonia where there are 169 stores. We calculate the average tax base in each postcode, and we allocate that value as a proxy of income corresponding to the store located in the same postcode. The second measure is an estimate of household income provided by the chain. For marketing purposes, the chain has asked a consultancy firm to estimate household income combining customers' own responses to the chain's loyalty card registration questionnaire and area-level information (e.g. education, population density, housing, employment and type of occupation). Income groups were defined as follows: (i) low (household income below €13.3k); (ii) low-middle (between €13.3k and €18.4k); (iii) middle (between €18.4k and €27.1k); (iv) middle-high (between €27.1k and €39.8k), and (v) high (above €39.8k). We have aggregated the low and lower-middle income group into one group because of the sample size for each beverage type.

In Table 1 we report household demographic and socio-economic characteristics for the rest of Spain and Catalonian samples. Our sample includes about 27% of the population in Catalonia. In the sample from the rest of Spain, 15.72% of the households have children between 3 and 15 years compared to 16.98% in our Catalonian sample. About 4.1% in the rest of Spain sample have children younger than 3 years which is similar to our sample of Catalonian households. The average

age of the main shopper is almost 47 for both the rest of Spain sample and the Catalonian sample. This figure is similar to the Spanish and Catalonian general population, where the average age is 43 and 42, respectively (Instituto Nacional de Estadistica). The percentage of female main shoppers in our Catalonian sample (72.35%) is higher than the percentage of women in the general Catalonian population older than 18 years (51.7%) (Instituto Nacional de Estadistica). Whilst in our Catalonian sample most households are in the middle two income quartiles, in the sample from the rest of Spain most households are in the top two income quartiles. We also report that there is a 10.71 euros difference between total monthly expenditure in Catalonia and the rest of Spain.

Our analyses are based on each household's *monthly* purchases at each store. We observe multiple beverage types for each household-month-year-store level. We consider 12 beverage types: (i) Pops such as Fanta, Sprite, Seven Up, Ginger Ale, tonic etc.; (ii) Colas such as Coca Cola, Pepsi etc.; (iii) Teas, Horchata and Vegetable drinks with soya, avena etc.; (iv) Isotonic drinks such as Powerade, Gatorade etc.; (v) Energy drinks such as Red Bull, Burn, Monster etc.; (vi) Water still or fizzy, Sifon, mineral water etc.; (vii) Juices and smoothies; (viii) Milkshakes, coffees, fresh and long life milks; (ix) Liquors and Vermouth; (x) Wines; (xi) Cavas or sparkling wines; and (xii) Beers. After splitting the eight soft drinks categories into the three segments of the tax (i.e. low sugar (0–5gr/100 ml); medium sugar (5–8gr/100 ml; and high sugar ((>8gr/100 ml)), we collapse the data into 26 beverage categories. Using these 26 beverage categories allows us to explore whether household responses differed for untaxed and taxed beverages. Our sample includes 11,648,625 observations for 884,843 households (of whom 823,095 are in Catalonia and 61,748 in the northeast area of Spain) and 301 stores (of which 277 are in Catalonia and 24 in northeast Spain).
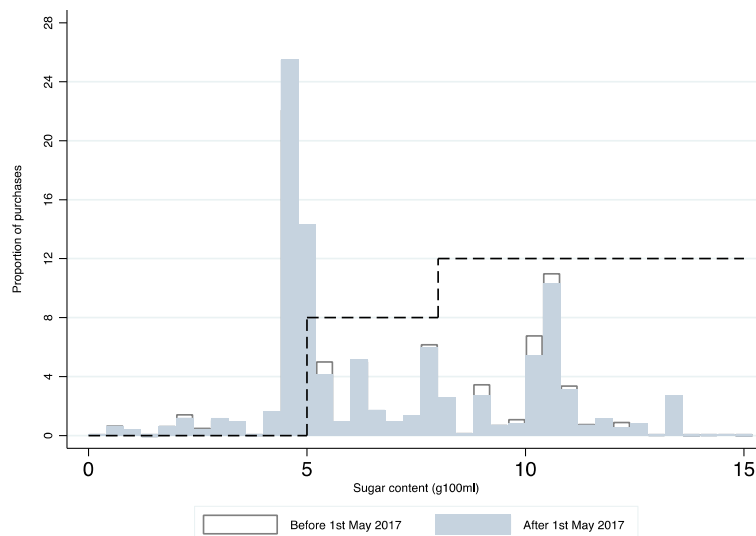
In Fig. 1 we plot the distribution of sugar content in grams per 100 ml of beverages bought in Catalonia before (white histograms) and after (grey histograms) the SSB tax was introduced. Overall, there is a reduction in the proportion of purchases with sugar content above 5 g and above 8 g per 100 ml bought after the tax was introduced. We use the two-sample Kolmogorov-Smirnov test and reject at the 1% level the null hypothesis that the before- and after-tax samples are drawn from the same distribution. This reduction is largest at the margins of the tax rate, particularly for beverages with more than 8 g of sugar per 100 ml.

Additional descriptive statistics on prices, purchased quantity and expenditure are presented in Appendix A (Figure A.1 and Table A.1). In order to speak to the representiveness of our sample, we compare some figures of average expenditures in our sample and the national one without presenting them in a Table. The average annual alcohol expenditure in our sample is €208 which is higher than the national alcohol expenditure of €161 (Instituto Nacional de Estadistica, 2016). The average national non-alcohol expenditure is €251, more than half the one in our sample, €444. While expenditure on liquors in our sample (€23) is comparable to the national one (€26), expenditure on wine and beers is larger in our sample (for wine it is €76 compared to €63; and for beers it is €94 compared to 58€). The national average expenditure on juices is €34.12, lower than €50 in our sample. Similarly, expenditure on isotonic drinks in our sample is double the national expenditure (€12.8 v. €6.3). Also, households in our sample spend €4.42 on juices, more than the national average of €3.63. Overall, our sample of households spend more on beverages than the national sample, this is not suprising given that compared to the national sample more households in our sample belong to the top income quartiles.

4. Econometric strategy

4.1. Main models

We start by examining the effect of the SSB tax on quantity of beverages and of sugar purchased by estimating the following DiD model:

Table 1
Household descriptive statistics.

	Rest of Spain	Catalonia
Household demographics		
Female	73.83%	72.35%
Children between the age of 3–15	15.72%	16.98%
Children between the age of 0–3	4.09%	4.61%
Age	46.95 (21.46)	47.08 (31.54)
Household size	1.81 (1.67)	1.85 (1.67)
Loyalty customer		
Dropped long-term	20.55	24.09
Sporadic	38.49	41.74
Shared	19.81	16.89
Loyal	21.15	17.28
Economic capacity		
Low & Lower-middle	9.29	14.71
Middle	27.57	35.77
Middle-High	30.49	32.05
High	32.65	17.47
Total expenditure	92.86 (103.78)	103.57 (117.44)
Number of households	61,748	823,095

Note: Disaggregated sample size of 113,744,214 refers the item-level data. White histograms indicate sugar content before 1st May 2017, grey histograms indicate sugar content on or after 1st May 2017. Catalonian sample only. Black dashed line indicates the SSB tax thresholds at 5 and 8 gr./100ml, respectively.

Fig. 1. Distribution of sugar content before and after the SSB tax.

$$\ln y_{jht} = \alpha + \chi_1 (Catalonia_h \times \tau) + \chi_2 Catalonia_h + \beta \ln x_{ht} + \eta_j t + \lambda_{js} + u_{jht} \tag{1}$$

where j indicates each of 26 beverage categories; h is the household and t is the year and month. We estimate equation (1) with two separate models: i) where the dependent variable $\ln y_{jht}$ indicates the (natural) logarithm of quantity (in litres); and ii) where the dependent variable $\ln y_{jht}$ indicates the (natural) logarithm of sugar of each j beverage category bought by household h in month t. $Catalonia_h$ is a dummy variable that is equal to one if household h shops in a Catalan store and zero otherwise. The time dummy τ is equal to one on or after May 1, 2017, when the SSBs tax was introduced. Hence, there is temporal variation in the time of the SSB tax introduction and spatial variation as the tax only occurred in Catalonia and not in the rest of Spain. λ_{js} are the spell fixed effects, where the spell-level heterogeneity is defined as $\lambda_{js} \equiv \theta_{jh} + \psi_{js(h,t)}$ (Abowd et al., 1999; Andrews et al., 2006) with s indicating the store where household h shops. We denote store fixed effects by $\psi_{js(h,t)}$ such that $\psi_{js(h,t)} \times t$ are store and time interactions. We control for month-year dummies, t, to capture seasonality in purchases. u_{jht} is a random noise. Total beverage spending by household h at time t is denoted by x_{ht} and proxies the household budget. We add a small value to the zeros before taking the logarithm, corresponding to 5% of the total observations. The simultaneous nature of quantity and expenditures implies that they are jointly determined in equation (1) leading to potentially biased estimates of β. We deal with this issue in two ways. First, we exploit the panel structure of the data and include spell fixed effects $\lambda_{s,j}$ exploiting *within* household-store changes in purchases. These would allow us to capture any time-invariant omitted factors affecting both quantity and expenditure. Second, the literature instruments for total expenditure using expenditure on fast moving goods (Griffith et al., 2018). As we do not have data on the amount of expenditure spent on non-food items, by assuming separability between beverage expenditure and other expenditure, we instrument total beverage expenditure with non-beverage expenditure (including both food and non-food expenditure). We are interested in χ_1 capturing the effect of the introduction of the SSB tax on the quantity of beverages and sugar bought in Catalonia compared to the rest of Spain.

There are four potential weaknesses in our model specifications.

Firstly, we assume the composition of households shopping in Catalonia and in the rest of Spain does not change in response to the tax. In principle, it is possible that households aware of the tax shop in close-by cities in the rest of Spain. We test for these potential spillovers in two ways. First, we test whether household shopping trips changed systematically between Catalonia and the rest of Spain. We estimate store-level models of the total number of shopping trips controlling for month-year dummies, and a dummy equal to one for trips occurred on/after the May 1, 2017 and interacting this time dummy with Catalonia (which is equal to one for trips occurred in Catalonia). Second, we re-estimate equation (1) dropping 13 stores located in postcodes close to the border with the rest of Spain, where the tax was not implemented.

Secondly, we assume that SSB purchases trend in a similar way in Catalonia and the rest of Spain. We investigate this in two ways. First, in Figure A.1 we plot the average monthly quantity and prices of SSBs in Catalonia and the rest of Spain prior to the May 1, 2017, when the tax was introduced. Although SSBs quantity (prices) are lower (higher) in Catalonia than in the rest of Spain, the series follow a similar trend. Second, common trends are violated if purchased quantity in the rest of Spain and Catalonia is affected by different shocks or if common macroeconomic shocks affecting the rest of Spain and Catalonia differently also change their purchases. We test this assumption more formally by estimating a version of equation (1) prior to the introduction of the tax where we interact the Catalonia dummy with a series of month dummies. For each taxed and untaxed beverage category, in Figure A.2 we plot the coefficients of month dummies and Catalonia interactions with confidence intervals at 99% level.

Thirdly, the fiscal law, approved on the March 28, 2017, could have been reported on the media. As a result, households may have changed their shopping behaviour in anticipation of the tax by, for example, building up a stock of SSBs. These anticipation effects may overestimate the impact of the tax. It is worth mentioning that this was a period of political turmoil in Catalonia as in January 2017 the Government of Catalonia held a conference in Brussels on "The Catalan referendum". We have found archived newspaper articles from the 1st of May to the July 1, 2017 announcing the structure of the tax and the type of beverages affected. On the May 1, 2017 the SSB tax was covered by TV channels such as RTVE, Castilla-La Mancha Media, La Sexta and Antena

3. Governmental and medical information on the tax was provided by the Web Gencat of the government of Catalonia, Expansion, Ajuntament BCN and SemFYC on the 1st and May 2, 2017. It is unlikely that media articles published only shortly before the tax was introduced changed the behaviour of consumers in anticipation to the tax.

4.2. Heterogenous effects

We use information on customer characteristics provided by the supermarket chain in 2017. As this information is time-invariant, we re-estimate equation (1) for the following sub-samples: a) whether the household main shopper (the cardholder within family with the greater expenditure over the whole period) is female; b) whether the main shopper's age is under 40; c) whether the main shopper is a regular shopper; d) the income quartile of the household; d) the income quartile

of the area where the supermarket chain is located; e) whether there are any children in the household aged 0–3; f) whether there are any children in the household aged 3–16.

4.3. Mechanisms

Producers and retailers could change prices strategically so not to pass the tax through to consumers. First, we calculate the change in price before and after the introduction of the tax. Second, we simulate this change by calculating what the price should have been, given the tax structure. Finally, we estimate the pass-through using the DiD approach in equation (1), but using prices as outcomes. We are interested in the DiD coefficient χ_1 measuring the change in price induced by the Catalonia tax. We then calculate the "pass-through" by dividing χ_1 by the tax rate for that specific beverage (Rojas and Wang, 2020; Berardi et al.,
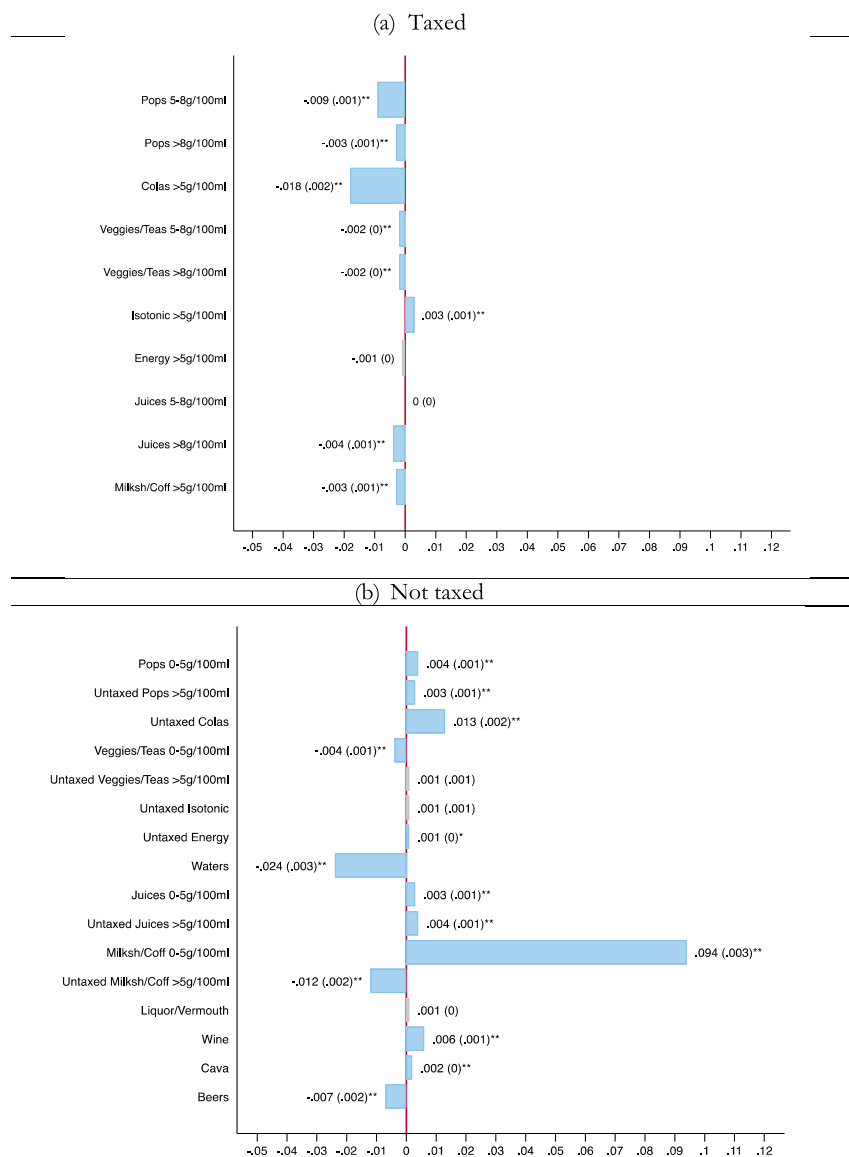
Note: Sample size is 11,648,625. The outcomes are the (natural) logarithm of quantity for each of the 26 beverage categories. Coefficients displayed are DiD coefficients of interaction of Catalonia dummy with time on/after the SSB tax was introduced. Standard errors clustered at household-level, shown in parentheses. Each of the 26 models control for year-month dummies, Catalonia, expenditures and spell fixed effects with non-beverage expenditure as instrument for prices beverage expenditure. *p<0.05, **p<0.01.

Fig. 2. Difference in Differences estimates of the beverage tax impact on quantity, by beverage category.

2016). For instance, for medium sugared pops we divide χ_1 by their tax rate, eight cents per litre. For colas and energy drinks we calculate the range of pass-through using the lowest and the highest values in the two-tiers of the tax rate.

One limitation is that the "pass-through" reflects the store pricing decision as well as the average household choice. To mitigate this, we investigate how the pass-through changes by income quartile of the household.

5. Results

5.1. Main models

Fig. 2 reports estimates of equation (1) where the 26 beverage categories are displayed according to their tax status (taxed beverages in panel (a) and untaxed beverages in panel (b)). Overall, we find a reduction in the quantity of taxed beverages and an increase in quantity of untaxed beverages. Most notably, we find a reduction in quantity of high sugar taxed colas by 1.8%, pops by 0.3%, and milkshakes and juices by 0.4% and 0.3%, respectively. There is also a reduction in the quantity of medium sugar taxed beverages such as pops by almost one percent and veggies/teas by 0.2%. Households have reduced purchases of higher sugar beverages and increased their lower sugar (untaxed) counterparts. For instance, the reduction in high sugar milkshakes has been paired with a 1.2% reduction in high sugar untaxed milkshakes and an increase in low sugar milkshakes by 9.4%. We find an increase in the quantity of untaxed low sugar colas (typically diet coke) by 1.3% and of low sugar pops and untaxed high sugar pops by 0.4% and 0.3%, respectively.
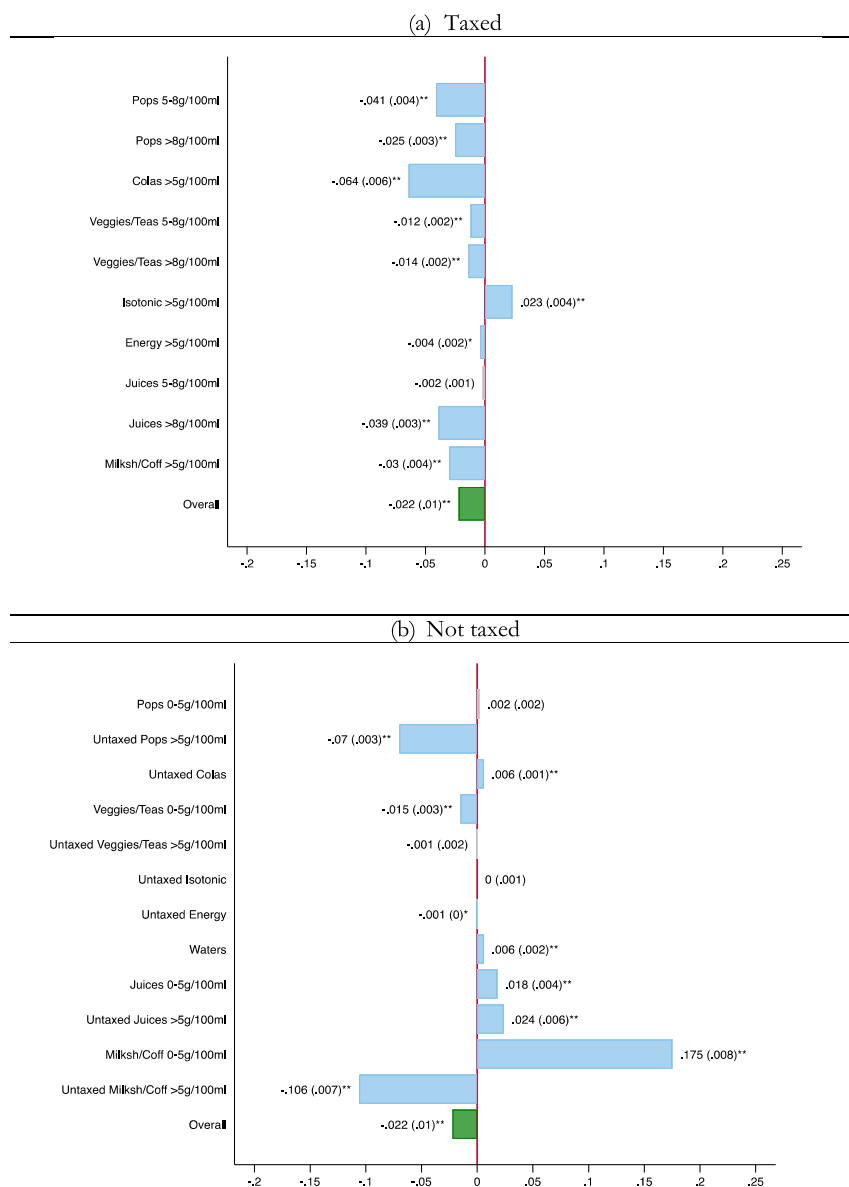
Note: Sample size is 11,648,625. The outcomes are the (natural) logarithm of sugar for each of the 26 beverage categories (in blue) and the (natural) logarithm of overall sugar (in green). All coefficients displayed are DiD coefficients of interaction of Catalonia dummy with time on/after the SSB tax was introduced. Standard errors clustered at household-level, shown in parentheses. Each of the 26 models control for year-month dummies, Catalonia, expenditures and spell fixed effects with non-beverage expenditure as instrument for beverage expenditure. Overall indicates the sugar DiD model for both taxed and untaxed beverages. *p<0.05, **p<0.01.

Fig. 3. Difference in Differences estimates of the beverage tax impact on sugar purchase, by beverage category.

In Fig. 3 we show that the introduction of the Catalonian SSB tax has led to an overall (for taxed and untaxed beverages) reduction in sugar purchases by 2.2% per household per month. We then investigate for which beverages households reduced their sugar purchases the most. We find that the SSB Catalonian tax has led to a 6.4% reduction in sugar purchases of high sugar colas, while increasing sugar purchases of their low sugar counterparts by 0.6%. We also find a reduction in sugar purchases of pops with 5-8gr and over 8gr per 100 ml by 4.1% and 2.5%, respectively. Sugar purchases of medium and high sugar veggies/teas is reduced by 1.2% and 1.4%, respectively.

We find that the reduction of quantity of high sugar milkshakes is accompanied by a 3% reduction in sugar purchase as well. Households reduce purchases of added sugar in juices (by almost 4%) and increase purchases of natural sugar contained in untaxed juices (by 2.4%) and low sugar juices (by almost 2%).

In Appendix A, we test the assumptions of our modelling strategy.

Specifically, we find no evidence of spillover effects because the total number of shopping trips in Catalonia did not change compared to the rest of Spain (Table A.2). We can reject the hypothesis that SSB quantities and prices in Catalonia do not follow the same trend as those in the rest of Spain (Figures A.1-A.2) and we show no evidence that stockpiling has affected our results (Figure A.3). Our results are robust to the inclusion of household and store fixed effects (Figure A.4) and a reduced aggregated number of 20 beverage categories (Figure A.5).

5.2. Heterogeneous effects

We find qualitatively similar patterns when looking at purchases by females as the majority of the main shoppers are indeed females (see Figure A.6). However, we find smaller reductions in high sugar colas by shoppers under the age of 40 (Figure A.7). Here we present estimates for regular shoppers and by household income, but we display the other
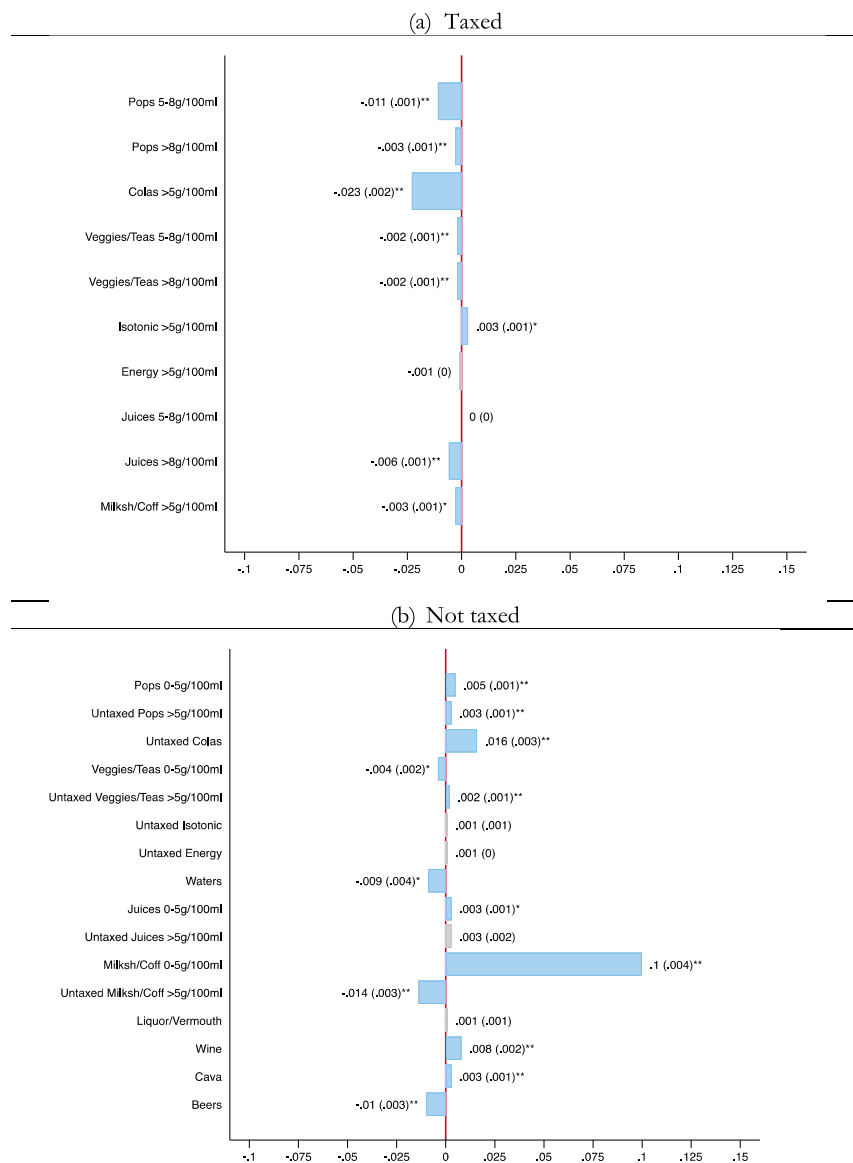
Note: Sample size is 6,750,646. The outcomes are the (natural) logarithm of quantity for each of the 26 beverage categories. Coefficients displayed are DiD coefficients of interaction of Catalonia dummy with time on/after the SSB tax was introduced. Standard errors clustered at household-level, shown in parentheses. Each of the 26 models control for year-month dummies, Catalonia, expenditures and spell fixed effects with non-beverage expenditure as instrument for beverage expenditure. *p<0.05, **p<0.01.

Fig. 4. Difference in Differences estimates of the beverage tax impact on quantity, by beverage category for regular shoppers.

estimates in Appendix A (Tables A.8-10). Overall, in Fig. 4 we report qualitatively similar results to Fig. 2. However, for regular shoppers we find a larger reduction in quantity purchased of high sugar colas by 2.3%. Regular shoppers have reduced high sugared taxed and untaxed milkshakes and increased low sugar milkshakes (by 10%). They have also increased quantity purchased of untaxed low sugar colas by 1.6%. We find similar results when defining regular shoppers as those who shop at this supermarket chain every month (results available upon request).

We report heterogenous effects of the policy by income in Fig. 5. *Ex-ante* we should expect relatively wealthier households to respond less to price changes because they can afford the SSB tax. However, as they may also be more educated, they might decide to consume fewer SSBs or the tax may be more salient for them as they realise that their beverage purchases are not healthy. We find that households in the middle quartile group respond to the tax by reducing their medium and high

sugared pops purchased quantity by 1.3% and 0.5%, respectively. Middle and middle-high income groups reduce their high sugared colas purchases by 1.7% and 1.8%, respectively. These patterns are similar when using the area-level measure of income (results available upon request).

We find the largest sugar reductions to occur for middle income groups (see Appendix A, Figure A.9). In additional analyses (Figure A.10), we find most reductions of sugar for regular customers to be even stronger than our main models.

5.3. Mechanisms

In Fig. 6 we plot the change in price one month before and one month after the introduction of the tax (blue shaded and labelled as "actual") alongside the simulated change (shaded in red), that is, what the change in price should have been, given the tax structure. For the majority of
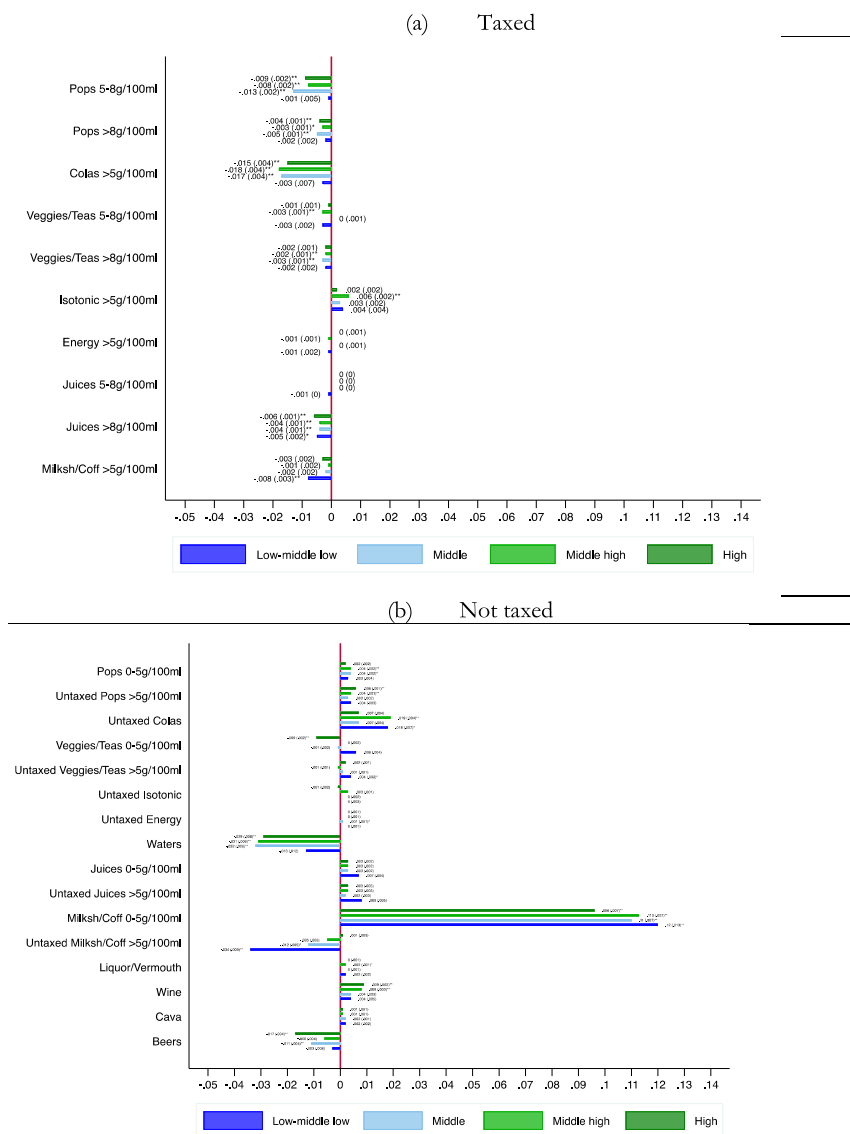
Note: Sample sizes are 1,402,760; 3,590,260; 3,409,454 and 2,087,007, respectively, for each of the four income quartiles. The outcomes are the (natural) logarithm of quantity for each of the 26 beverage categories. Coefficients displayed are DiD coefficients of interaction of Catalonia dummy with time on/after the SSB tax was introduced. Standard errors clustered at household-level, shown in parentheses. Each of the 26 models control for year-month dummies, Catalonia, expenditures and spell fixed effects with non-beverage expenditure as instrument for beverage expenditure. "Low middle low", "Middle", "Middle high" and "High" are quantity models for the sub-samples of shoppers in each of the income quartiles. *p<0.05, **p<0.01.

Fig. 5. Difference in Differences estimates of the beverage tax impact on quantity, by beverage category and household income.
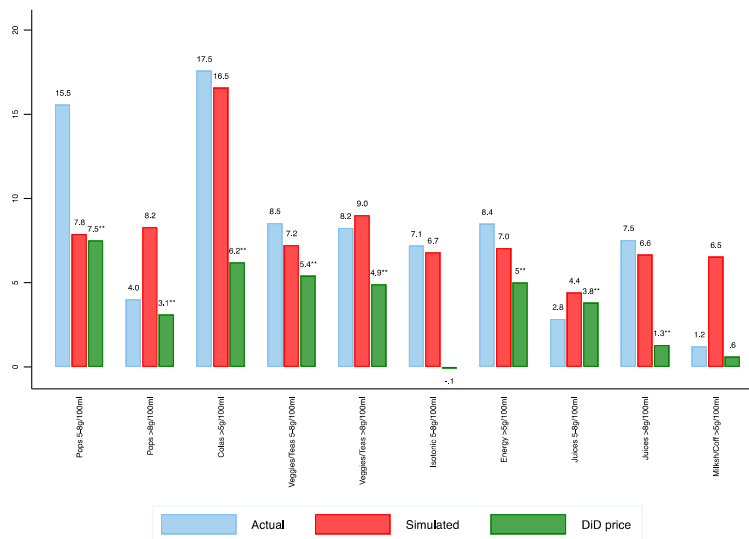
Note: Blue histograms indicate the average price change before the introduction of the SSB tax compared to the after period (labelled as "Actual"). Red histograms indicate what the change in price should have been, given the tax structure (labelled as "Simulated"). Green histograms indicate the coefficients from DiD models of interaction of Catalonia dummy with time on/after the SSB tax was introduced. Each of these DiD models control for year-month dummies, Catalonia, and store fixed effects. $*p<0.05$, $**p<0.01$.

Fig. 6. Beverage tax impact on prices, by beverage category.

beverage categories, the supermarket chain has increased the price more than it was warranted by the tax. The price increase of medium sugar veggies and isotonic drinks, and of high sugar milkshakes is not far off the simulated one. When we plot the price change from the DiD models, we find large differences for some beverages that could be explained as follows. Firstly, the actual and simulated price changes are unconditional differences. Secondly, it could indicate that prices were changing differentially in treated and control areas. To explore this issue, we plot the price trends in Catalonia and the rest of Spain in Figure A.1. We find that before the tax was introduced prices were broadly following the same trend in the treatment and control areas.

We find there is only a partial pass-through, but its size varies by beverage type. Although it was compulsory to pass-through the tax and supermarkets could retain profits from it, supermarkets could decide which beverages were taxed. Most beverages have a pass-through higher than 20% (except juices with an 11% pass-through), whereas the WHO recommends prices increase by 20%. Medium sugar pops have the highest pass-through at 94%. Colas and energy drinks have a pass-through between 52%-76% and 42%–63%, respectively. Whilst high sugar pops and veggies have a pass-through of 26% and 41%, respectively, medium sugar veggies and juices have a pass-through of 68% and 48%, respectively.

Broadly, we find that the pass-through has similar sign and size across income groups (Figure A.11), although it is slightly higher for medium sugared pops (for low-income groups) and for medium/high sugared colas (for high income groups).

6. Discussion and conclusion

We examine the impact of a tax on sugar-sweetened beverages implemented in Catalonia. Our contribution in this study is to investigate its impact on the full basket of beverages. An increasing number of studies is examining how sugar taxes affect consumer and retailer behaviours, but not much is known about the impact of two-tier taxes, particularly when it comes to potential substitution effects (Cawley et al. (2019a, 2019b)). We estimate quantity and sugar purchases by exploiting the fact that the tax was implemented in Catalonia but not in

the rest of Spain with a DiD approach. We find that in response to the SSB tax, households reduce purchases of taxed beverages. Most notably, we find a reduction in purchased quantity of high sugar taxed colas by 1.8%, pops by 0.3%, and milkshakes and juices by 0.4% and 0.3%, respectively. Although it may appear that these numbers are small, they are not so when considering that at baseline milkshakes have the second highest sugar amount after colas. Households have reduced higher sugar (taxed) beverage and increased their lower sugar (untaxed) counterparts.

How important are these reductions in sugar for health? As the tax reduced sugar purchases by 2.2% per household per month and an average household consumed 103.61 g of sugar before the tax introduction, there is a reduction of about 2.3 g per month per household (equivalent to 9.2 calories). As in Catalonia there are 2,993,600 families (National Institute of Statistics, 2017) and 6,667,342 people over the age of 10, the total reduction in sugar intake is 6824 g per month for the whole Catalonian population, and the average reduction per capita attributable to the tax is just 3.7 calories per month.

We find relatively larger reductions in purchases of medium and high sugar pops, and colas for regular and relatively wealthier customers. We suggest that for these households the tax may be more salient and inform them that their purchases are relatively less healthy. An average regular customer buying medium sugar pops would reduce up to ten calories per month, considering the 5% reduction of sugar intake from this beverage category. According to the ESCA (Health Survey of Catalonia), around 7.56% of people with obesity (around 80,000 people) drink one or more pops or colas with added sugar daily. If they reduced their sugar intake from pops by 5% (as we have shown in our models), then there would be a reduction of six calories per day (167 calories per month).

It is hard to compare these estimates to other studies because of differences in the tax structure across countries and because of different beverage aggregations. We find a reduction in high sugar (taxed) juices and an increase in purchased quantity of low sugar and untaxed juices by 0.3% and 0.4%, respectively. Our results show much smaller reductions than in Royo-Bordonada et al. (2019) and Vall Castello and Lopez-Casasnovas (2020). However, the former study examines purposely collected consumption data on a specific population of young

people in poorer districts of Madrid and Barcelona. The latter focuses only on 71 beverages using a before and after analysis. Cornelsen et al. (2017) find a reduction in the number of SSBs by 11% after 12 weeks from the introduction of food policies in Jamie's Italian restaurant. They also find a reduction of 1% and 35% in sales of diet colas and fruit juices, respectively. We actually find almost a 2% reduction in medium/high sugar colas purchases and a 1.3% increase in untaxed low sugar colas. We observe a 0.4% reduction in high sugar juices. The findings by Quirmbach et al. (2018) are more comparable because the classification of beverages resembles the structure of the U.K. They find that a 1% increase in price reduces purchase of high and medium sugar SSB by 0.7% and 0.24%, respectively. They find an increase in low sugar SSB and juice purchases by 0.06% and 0.15%, respectively. Quirmbach et al. (2018) find an increase in purchases of lager by 0.23% whereas we find a decrease in beer purchases by 0.7%. In their study a 1% increase in the price of medium-sugar SSBs reduced purchases of medium sugar SSBs by 0.75% and of juices by 0.09%. However, there is an increase in purchases of spirits by 0.29%. We also find increases in wine and cava purchases by 0.6% and 0.2%, respectively.

Our finding that the tax has a stronger impact on wealthier customers is similar to Vall Castello and Lopez-Casasnovas (2020). Our findings also compare to Nakamura et al. (2018) who find that the Chilean tax reduced soft drink purchasing amongst higher socioeconomic groups. However, other studies have shown different results. For instance, Sharma et al. (2014) find demand for regular soft drinks by high-income households to be slightly less responsive to a 20% *ad valorem* tax with reductions in consumption is 13%, 14.9% and 15% for high-, middle- and low-income households. They also find larger reductions in fruit drinks consumption for middle- and high-income groups (37% and 12%) compared to low-income groups (3%). This difference may be due to how they have defined socio-economic groups as they split their sample in three groups (low-income, middle-income and high-income households) based on their income.

Our study has some limitations. Firstly, we only have time-invariant socio-economic characteristics. However, it is unlikely the policy has affected households' socio-economic status. Secondly, our results reflect the behaviour of households shopping at one supermarket chain which may differ from other households. Thirdly, as we only have information about sugar content at one point in time, we cannot test whether reformulation has not occurred. Finally, we only have data from loyalty card customers who could behave differently from other customers. After comparing the average expenditure in our sample to the national one, we have shown that our sample of households spend more on beverages than the national sample. Therefore, our results are representative of an average household shopping at a middle-range supermarket.

Our results have policy implications for other countries that have implemented similar fiscal measures on SSBs such as the U.K., where a similar tax rate has been introduced in April 2018. As the U.K. Soft Drink Industry Levy was announced in March 2016, there is evidence that soft drink makers such as Coca-Cola, Britvic and Lucozade Ribena Suntory and retailers such as Tesco, Asda and Morrisons have reformulated drinks to be below the levy's threshold (Reuters, 2018). We cannot directly test whether reformulation has occurred in Catalonia, although it is unlikely to have occurred in one region and not in the rest of Spain. We find only a 2.2% overall reduction of sugar purchases, corresponding to a reduction of about four calories per person per month. We suggest three potential explanations for this result. First, as the Catalonia SSB tax was incorporated in the check-out price and was not making the headlines in the media at a time where the referendum was discussed, it is unlikely that was made salient to consumers. Nevertheless, the fact that our results are stronger for regular customers and for higher income (and possibly more educated) households may suggest that for some groups at least, the tax was salient. Second, there is substitution across beverages (e.g. low sugar milkshakes and colas). Finally, there is only a *partial* pass-through, but most beverages have a pass-through higher than 20%

(except juices with an 11% pass-through), the one recommended by WHO. Some studies find a 100% pass-through (Cawley et al., 2018a, 2018b; Berardi et al., 2016; Bergman and Hansen, 2010; Vall Castello and Lopez-Casasnovas, 2020; Leider et al., 2018), but most of them do not have a control group (except Cawley et al., 2018a,b; Leider et al., 2018). Other studies find a partial pass-through between 9% and 93% depending on country and beverage type (Cawley and Frisvold, 2017; Grogger, 2017; Bollinger and Sexton, 2018; Cawley et al., 2018a,b; Roberto et al., 2019; Rojas and Wang, 2020; Silver et al., 2017).

The Catalonian tax may provide some useful policy lessons. First, sugar taxes should be made more visible at check-out and should be advertised. Second, although the tiered structure may incentivise producers to reformulate their beverages, taxes should be implemented at the national level to make reformulation easier. Third, taxes may differently affect population groups. Reformulation could potentially change the direction of the heterogeneous effects, changing the behaviour of less wealthy households also. Finally, the list of taxed beverages should be more specific and appropriate enforcement should be put in place so that producers have to pass the tax through to consumers. However, even when implemented, we suggest SSB taxes to be accompanied by a wider approach to food policies that includes information campaigns, labelling and reformulation.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2021.113799.

Credit roles

Eleonora Fichera: Conceptualization, Methodology, Software, Formal analysis, Writing – original draft; Toni Mora: Conceptualization, Data curation, Visualization, Funding acquisition, Writing – review & editing; Beatriz G Lopez-Valcarcel: Resources, Writing – review & editing; David Roche: Data curation, Visualization.

References

Abowd, J., et al., 1999. High wage workers and high wage firms. Econometrica 67, 251–333.

Allais, O., Etilé, F., Lecocq, S., 2015. Mandatory labels, taxes and market forces: an empirical evaluation of fat policies. J. Health Econ. 43, 27–44.

Andrews, M., Schank, T., Upward, R., 2006. Practical fixed-effects estimation methods for the three-way error components model. STATA J. 6 (4), 461–481.

Barrientos-Gutierrez, et al., 2017. Expected population weight and diabetes impact of the 1-peso-per-litre tax to sugar sweetened beverages in Mexico. PloS One 12 (5).

Basto-Abreu, Ana, et al., 2019. Cost-effectiveness of the sugar-sweetened beverage excise tax in Mexico. Health Aff. 38 (11).

Berardi, N., Sevestre, P., et al., 2016. The impact of a 'soda tax' on prices: evidence from French micro data. Appl. Econ. 48 (41), 3976–3994.

Bergman, U.M., Hansen, N.L., 2010. Are excise taxes on beverages fully passed through to prices? The Danish evidence. FinanzArchiv: Public Finance Analysis, Mohr Siebeck, Tübingen 75 (4), 323–356.

Bollinger, B., Sexton, S., 2018. Local Excise Taxes, Sticky Prices, and Spillovers: Evidence from Berkeley's Soda Tax. Work Pap., SSRN, Rochester, N.Y. https://doi.org/10.2139/ssrn.3087966.

Caro, J., Smith-Taille, L., et al., 2017. Designing a food tax to impact food-related non-communicable diseases: the case of Chile. Food Pol. 71, 86–100.

Cawley, J., Frisvold, D., 2017. The pass-through of taxes on sugar-sweetened beverages to retail prices: the case of Berkeley, California. J. Pol. Anal. Manag. 36 (2), 303–326.

Cawley, J., Crain, C., Frisvold, D., Jones, D., 2018a. The pass-through of the largest tax on sugar-sweetened beverages: the case of Boulder, Colorado. NBER WP 25050. https://www.nber.org/papers/w25050.

Cawley, J., Frisvold, D., et al., 2019a. The impact of the philadelphia beverage tax on purchases and consumption by adults and children. J. Health Econ. 67, 102225. September.

Cawley, J., Thow, A., et al., 2019b. The economics of taxes on sugar-sweetened beverages: a review of the effects on prices, sales, cross-border shopping and consumption. Annual reviews 39, 317–338.

Cawley, J., Willage, B., Frisvold, D., 2018b. Pass-through of a tax on sugar-sweetend beverages at the philadelphia international airport. J. Am. Med. Assoc. 319, 305–306.

Chetty, R., Looney, A., Kroft, K., 2009. Salience and taxation: theory and evidence. Am. Econ. Rev. 99 (4), 1145–1177.

Chou, S.-Y., Rshad, I., Grossman, M., 2008. Fast-food restaurant advertising on television and its influence on childhood obesity. J. Law Econ. 51, 599–618.

Colchero, M., Guerrero-López, C.M., Molina, M., Rivera, J.A., et al., 2016a. Beverage sales in Mexico before and after implementation of a sugar sweetened beverage tax. PloS One 11 (9), e0163463.

Cornelsen, L., Smith, R., 2018. Viewpoint: soda taxes – four questions economists need to address. Food Pol. 74, 138–142.

Colchero, M., Popkin, B., Rivera, J.A., Ng, S.W., et al., 2016b. Beverage purchases from stores in Mexico under the excise tax on sugar sweetened beverages: observational study. BMJ 352 h6704.

Cornelsen, L., Mytton, O., et al., 2017. Change in non-alcoholic beverage sales following a 10-pence levy on sugar-sweetened beverages within a national chain of restaurants in the UK: interrupted time series analysis of a natural experiment. J. Epidemiol. Community 71 (11), 1107–1112.

Diari Oficial de la Generalitat de Catalunya, 2017. DISPOSICIONS - DEPARTAMENT DE LA PRESIDÈNCIA. No. 5/7340, 3 30. Retrieved from. http://aplicacions.economia.gencat.cat/wpres/AppPHP/2017/pdf/VOL_L_MES.pdf.

Escobar, M., Veerman, L., et al., 2013. Evidence that a tax on sugar sweetened beverages reduces the obesity rate: a meta-analysis. BMC Publ. Health 13 (1072).

Falbe, J., Thompson, H., et al., 2016. Impact of the Berkeley excise tax on sugar-sweetened beverage consumption. Am. J. Publ. Health 106 (10), 1865–1871.

Fichera, E., von Hinke, S., 2020. The response to nutritional labels: evidence from a quasi-experiment. J. Health Econ. 72 (102326).

Fiscal Studies Institute, 2013. Difusión de microdatos fiscales. Retrieved from http://www.ief.es/recursos/estadisticas/fuentes_tributarias.aspx. .

Griffith, R., von Hinke, S., Smith, S., 2018. Getting a healthy start: the effectiveness of targeted benefits for improving dietary choices. J. Health Econ. 58, 176–187.

Grogger, J., 2017. Soda taxes and the prices of sodas and other drinks: evidence from Mexico. Am. J. Agric. Econ. 99 (2), 481–498.

Grummon, A., Lockwood, B., et al., 2019. Designing better sugary drink taxes. Science 365 (6457).

Heike, S., Taylor, C., 2013. A critical review of the literature on nutritional labeling. J. Consum. Aff. 120–156.

Hm Revenues & Customs, 2017. Statutory Instruments. Retrieved from Soft drinks industry levy. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/651793/Draft_Statutory_Instrument_-_The_Soft_Drinks_Industry_Levy_Regulations_2017.pdf.

Horsley, et al., 2014. The proportion of unhealthy foodstuffs children are exposed to at the checkout of convenience supermarkets. Publ. Health Nutr. 17 (11), 2453–2458.

Instituto Nacional de Estadistica. (n.d.). Series detalladas. Retrieved from https://www.ine.es/dynt3/inebase/es/index.htm?padre=1894&capsel=1900.

Ippolito, P., Mathios, A., 1990. Information, advertising and health choices: a study of the cereal market. Rand J. Econ. 459–480.

Ippolito, P., Mathios, A., 1995. Information and advertising: the case of fat consumption in the United States. Am. Econ. Rev. 85 (2), 91–95.

Johnson, R., Appel, L., et al., 2009. Dietary sugars intake and cardiovascular health: a scietific statement from the American Heart Association. Circulation 120, 1011–1120.

Johnson, R., Segal, M., et al., 2007. Potential role of sugar (fructose) in the epidemic of hypertension, obesity and the metabolic syndrome, diabetes, kidney disease, and cardiovascular disease. Am. J. Clin. Nutr. 86, 899–906.

Lal, A., Mantilla-Herrera, A., et al., 2017. Modelled health benefits of a sugar-sweetened beverage tax across different socioeconomic groups in Australia: a cost-effectiveness and equity analysis. PLoS Med. 14 (6), e1002326.

Leider, J., Pipito, A., Powell, L., 2018. The Impact of the Cook County, Illinois, Sweetened Beverage Tax on Prices. Chicago: Ill.: Prev. Res. Cent. Univ. Chic.

Malik, V., Hu, F., 2011. Sugar-sweetend beverages and health: where does the evidence stand? Am. J. Clin. Nutr. 84, 274–288.

Malik, V., Hu, F., 2012. Sweeteners and risk of obesity and type 2 diabetes: the role of sugar-sweetened beverages. Curr. Diabetes Rep. 12, 195–203.

Malik, V., Schulze, M., Hu, F., 2006. Intake of sugar-sweetened beverages and weight gain: a systematic review. Am. J. Clin. Nutr. 84, 274–288.

Nakamura, R., Mirelman, A., et al., 2018. Evaluating the 2014 sugar-sweetened beverage tax in Chile: an observational study in urban areas. PLoS Med. 1539.

Nakhimovsky, S., Feigl, A., et al., 2016. Taxes on sugar-sweetened beverages to reduce overweight and obesity in middle-income countries: a systematic review. PloS One 11 (9), e0163358.

Oecd, 2017. OECD Health Statistics. www.oecd.org/health/health-data.htm.

Puig-Codina, L., Pinilla, J., Puig-Junoy, J., 2020. The impact of taxing sugar-sweetened beverages on cola purchasing in Catalonia: an approach to causal inference with time series cross-sectional data. The European Journal of Health Economics.

Quirmbach, D., Cornelsen, L., et al., 2018. Effect of increasing the price of sugar-sweetened beverages on alcoholic beverage purchases: an economic analysis of sales data. J. Epidemiol. Community Health 1–7.

Redondo, M., Hernandez-Aguado, I., Lumbreras, L., 2018. The impact of the tax on sweetened beverages: a systematic review. Am. J. Clin. Nutr. 108 (3), 548–563.

Reuters, 2018. Reuters Health News. Retrieved from. https://www.reuters.com/article/us-britain-sugar/britains-sugar-tax-on-soft-drinks-comes-into-effect-idUSKCN1HD1K2.

Roberto, C., Lawman, H., et al., 2019. Association of a beverage tax on sugar-sweetened and artificially sweetened beverages with changes in beverage prices and sales at chain retailers in a large urban setting. J. Am. Med. Assoc. 321 (18).

Rojas, C., Wang, E., 2020. Do Taxes on soda and sugary drinkinks work? Scanner data evidence from Berkeley and Washington State. Econ. Inq. 59 (1), 95–118.

Royo-Bordonada, M., Fernández-Escobar, C., et al., 2019. Impact of an excise tax on the consumption of sugar-sweetened Open Access beverages in young people living in poorer neighbourhoods of Catalonia, Spain: a difference in differences study. BMC Publ. Health 19, 1553.

Sharma, A., Hauck, K., Hollingworth, B., Siciliani, L., 2014. The effects of taxing sugar-sweetened beverages across different income groups. Health Econ. 1159–1184.

Silver, L., S, Ng, et al., 2017. Changes in prices, sales, consumer spending, and beverage consumption one year after a tax on sugar-sweetened beverages in Berkeley, California, US: a before-and-after study. PLoS Med. 14 p. e1002283.

Sturm, R., Cohen, D., 2009. Zoning for health? The year-old ban on new fast-food restaurants in South LA. Health Aff. 28 (6), w1088–1096.

Teng, A., Jones, A., et al., 2019. Impact of sugar-sweetened beverage taxes on purchases and dietary intake: systematic review and meta-analysis. Obes. Rev. 20 (9), 1187–1204.

Vall Castello, J., Lopez-Casasnovas, G., 2020. Impact of SSB taxes on sales. Econ. Hum. Biol. 36.

Veerman, J., Sacks, G., et al., 2016. The impact of a tax on sugar-sweetened beverages on health and health care costs: a modelling study. PloS One 11 (4), e0151460.

World Health Organization, 2010. Global status report on noncommunicable diseases. Geneva. http://www.who.int/nmh/publications/ncd_report_full_en.pdf.

World Health Organization, 2015. Fiscal policies for diet and prevention of noncommunicable diseases: technical meeting report. Geneva. http://apps.who.int/iris/bit stream/10665/250131/1/9789241511247-eng.pdf?ua=1.

Zhong, Y., Auchincloss, A., et al., 2018. The short-term impacts of the Philadelphia beverage tax on beverage consumption. Am. J. Prev. Med. 55, 26–34.