The impact of the French soda tax on prices and purchases: An ex post evaluation

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Abstract

We evaluate the ex-post effects of the tax on sweetened non-alcoholic drinks introduced in France in January 2012. The evaluation is based on a natural experiment, using household purchase data drawn from home scan consumer data from two French regions, and two neighboring Italian regions over the twelve months preceding and following the enforcement of the tax. We adopt a Difference-in-Difference model, allowing for fixed household and differential fixed time effects to estimate the impact of the tax on average prices, unit values and purchased quantities for a set of non-alcoholic drink categories. Our results suggest that the tax is fully transmitted to the taxed drinks. We estimate real price increases using two independent data sources, the national consumer price indices and the regional data from the home scan data-set, and our findings are consistent, pointing at increases between 7.1% and 8.4% for soft drinks. We also find evidence of a reduction in quantities of taxed drinks purchased for home consumption. We estimate a 15% reduction for the average household, but the impact of the tax is higher for household with children (above 16%) and for households in the top consumption quartile (around 25%).

JEL classification: I18, D12

Keywords: Soda tax, Difference in Difference, Policy Evaluation

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1 Introduction

Taxation of sweetened beverages (SBs) as a mean to reduce the risk of excess weight and non-communicable diseases, especially in children, has been a key component of nutrition policies for many governments over the last decade. However, the ex-post empirical evidence on the effectiveness of these taxes is still limited. In this study, we evaluate the impact of a tax on sweetened non-alcoholic drinks introduced in France in January 2012, and we provide quasi-experimental evidence on its effect on prices and purchased quantities.

The introduction of taxes on soft drinks dates back to 1933, when California introduced a 7% sales tax. By 2014, 34 US states had introduced a soda tax[1], and between 2014 and 2016 the introduction of a city-level tax was approved in seven US cities, five of them following popular ballots (Paarlberg et al., 2017). However, the main outcomes of these taxes has been the generation of revenues rather than actual changes on behaviors. This has been explained with the relatively low level of the taxes, all below 10% as opposed to the 20% level indicated by experts as the minimum to generate significant changes in weight and health outcomes (Briggs et al., 2013; Mytton et al., 2012; Fletcher et al., 2010). Outside the US, according to the Nourishing data-base[2], at least 15 governmentseveral have enacted soda taxes over the recent years, including an 18% tax on sugary drinks introduced in Chile in 2015 (Guerrero-López et al., 2017) and a $ 0.07 per liter tax in Mexico (Colchero et al., 2017). In Europe, taxes on soft drinks are currently implemented in Hungary (from 2011, $ 0.24 per liter), Belgium (from 2016, €0.068 per liter), Norway (from 1981, $ 0.40 per liter), and Finland, where an excise duty tax exists since 1940 and currently amounts €0.22 per liter for soft drinks exceeding 0.5% sugar content, €0.11 per liter otherwise. The French soda tax was introduced in January 2012 and set to €0.0716 per litre. It applies to all sweetened drinks, including sugar substitutes used in diet drinks, and is paid by manufacturers, processors and importers.

Despite the growing spread of this type of fiscal measures across the World, there are conflicting visions about their effectiveness in reducing consumption of sugary drinks. The evidence base is still incomplete, and the findings inconsistent, not least because studies are heterogeneous in terms of design, tax levels and aims. Until recently, most of the quantitative evidence has been based on demand simulations. These simulations necessarily rely on key empirical assumptions on the pass-through from producer prices to retail prices, and rest on elasticities and behavioural parameters whose estimates depend heavily on the demand model specification (Cornelsen et al., 2016) and the variability in price

[1] Chriqui JF, Eidson SS, Chaloupka FJ. State Sales Taxes on Regular Soda (as of January 1, 2014) - BTG Fact Sheet. Chicago, IL: Bridging the Gap Program, Health Policy Center, Institute for Health Research and Policy, University of Illinois at Chicago; 201 `www.bridgingthegapresearch.org`

[2] World Cancer Research Fund, `http://www.wcrf.org/int/policy/nourishing-framework`

data relative to the tax level. Based on the existing evidence, a report published by the World Health Organization in 2016 suggests that these targeted taxes should raise the price of targeted drinks of at least 20% to generate meaningful impacts in terms of calorie intakes, weight and risk of non-communicable disease[3].

The rising adoption of soda taxes in recent years, as well as the increasing availability of purchase data, should now allow a more accurate ex post assessment of their effects, at least in the short-term. Recent ex-post evaluations are suggestive of soda taxes generating significant reduction in purchased quantities. Colchero et al. (2017) exploit panel data on food and drink purchases of 6,645 Mexican households to estimate an average reduction of 7.6% in purchased volumes of taxed beverages in Mexico over the first two years of the tax implementation. The 2014 Mexican tax amounted to 1 peso per litre (about 0.008 USD at that time), and a previous study (Colchero et al., 2015) had shown a full pass-through to consumer prices.

The ex-post evidence gathered from the city-level Berkeley soda tax is particularly interesting for two reasons. First, the level of the tax ($ 0.34 per litre) is much higher than most of the fiscal measures adopted elsewhere. Second, the tax was adopted in November 2014 as a ballot measure, and the debate prior to the vote this is likely to have generated information effects on consumption beyond the mere price effect. Two studies (Falbe et al., 2016; Silver et al., 2017) have evaluated the impact of the tax exploiting neighbouring areas as control groups. As for the other ex-post studies, there was robust evidence of a pass-through to retail prices. The estimates also show a large reduction in purchased quantities of taxed drinks over the first year of implementation, estimated at -9.6% by Silver et al. (2017) and at 21% by Falbe et al. (2016), although both studies also register an increase in purchases in the neighbouring (control) areas, 6.9% and 4%, respectively.

To the bast our knowledge, the only ex post evaluation on the French soda tax is the one by Berardi et al. (2016) that focuses on the effect of the excise tax on retail prices, and there are no studies looking at the ultimate impact on purchases or consumption. Based on a large data-set on retail prices, Berardi et al. (2016) consider a sub-set of non-taxed goods with pre-tax price patterns similar to the taxed categories as a natural control group. Their soda category, which includes regular and diet sodas, exhibits an average pass-through around 7 euro-cents per liter over the first 6 months of the tax. Fruit drinks and flavored waters show a slightly smaller pass-through. These empirical findings are consistent with a simulation-based study by Bonnet and Réquillart (2013) based on pre-tax data, that predicted that French firms would be likely to transmit,

[3]WHO, Fiscal Policies for Diet and Prevention of Noncommunicable Diseases: technical meeting report, 5-6 May 2015, Geneva, Switzerland, `http://apps.who.int/iris/bitstream/10665/250131/1/9789241511247-eng.pdf?ua=1`

and even over-transmit, cost changes or excise taxes to consumers.
In this study, we evaluate the impact of the French soda tax on different outcome measures: (a) retail (shelf) prices; (b) actual purchase unit prices, that reflect substitutions and quality choices by consumers after the tax; (c) purchased quantities. We also explore whether the tax has had differential effects on two specific target groups, households with children, and households with a heavy consumption of taxed drinks. Our evaluation is based on panel household purchase data collected through home scan devices in four regions in the twelve months preceding and following the introduction of the tax. We consider two French regions (Rhone Alpes and Provence-Alpes-Cote d'Azure) where households are exposed to the tax, and two neighboring Italian regions (Piemonte-Val D'Aosta and Liguria) that act as a natural control group. Because of potential structural differences among these regions, we adopt a Difference-in-Difference panel regression to control for selection on non-observable variables, allowing for fixed household and time effects. Our method rests on the assumption that any border effect could be ignored. We consider this assumption reasonably safe given the dimensions of the four regions, as only a very small number of households in our sample would be located at a distance which makes the cross-border trip convenient [4].
The paper is structured as follows. The key elements of the French soda tax are summarized in Section 2, the commercial panel data are described in Section 3, and the evaluation methods are presented in Section 4. Section 5 reports the main results of our evaluation, and some conclusions are drawn in Section 6.

2 Policy background

The French tax on sweetened soft drinks was incorporated in the 2012 French budget bill (Law No.2011-1977) and entered into force on January 2012. It applies to all non-alcoholic beverages containing added sugar (e.g. sodas, fruit juice) or sweeteners (e.g. diet drinks) and amounts to 7.16 cents per litre excluding VAT, or 7.55 cents per litre at the retail level where a 5.5% VAT is applied. The tax is paid by manufacturers and processors in France and by French importers.
In its initial proposal[5], the tax was lower (3.58 cents per liter), it did not apply to artificially sweetened drinks and it was framed within the broader scope of the French National Nutrition and Health Program (NNHP) among public measures targeting eating patterns to promote healthier lifestyles. The explicitly stated rationale of the tax was originally to discourage the consumption of sugary and sweetened beverages and direct consumers towards other beverages.

[4]For example, someone living in Nice should drive about 25 miles to cross the border, and pay about €2.50, which correspond to about 33 litres of taxed drinks
[5]Projet de loi de finances pour 2012, 28 September 2011.

The proposal caused a strong opposition by the French Food Industry Association and by those producers holding the largest shares in the non-alcoholic beverage market[6]. The reference to the NNHP and to healthy eating objectives does not appear in the final text of the law, approved on December 2011, where the tax level is doubled relative to the original proposal.

3 Data

3.1 Price indices

The impact of the tax on retail prices and the extent of the pass-through is first assessed through national consumer price indices from the national statistical offices of France and Italy. The monthly time series from 2007 to 2016 are Consumer Price Indices as released by the National Statistical Offices, INSEE for France[7] and ISTAT for Italy. The most disaggregated available data refer to COICOP-5 digits for the following aggregate drinks: soft drinks (aggregating sweetened and diet beverages); mineral and spring waters; fruit and vegetable juices. In order to account for the potential effects of differential inflation rates (which in 2012 was +3% in Italy and +1.3% in Metropolitan France), we also considered a consumer price index for all items from the same sources.

Figure 1 displays the monthly price indices and is suggestive of a meaningful real price increase of soft drinks in France in the first two years of the tax implementation, whereas price patterns are substantially overlapping since 2014.

3.2 Homescan data

We use commercial home-scan data provided by EuroPanel, a joint venture between Kantar Worldpanel and GfK. Our data consist in random sample of French and Italian households living in four neighboring regions, Rhone Alpes and Provence-Alpes-Cote d'Azure in France and Piemonte-Val D'Aosta and Liguria in Italy. Data for the two French and the two Italian regions are provided by Kantar WorldPanel France and GfK Italy, respectively.
The harmonized data-set consists of 2,928 French households and 400 Italian households observed over the period between 1 January 2011 and 31 December 2012, conditional on at least one purchase of non-alcoholic beverages in each of the two year. Thus, for each household, at least one observation before and after the tax is available. Expenditures and purchased quantities are aggregated

[6]USDA Foreign Agricultural Service, 2011, France to tax soft drinks - U.S. Companies to pay the most, GAIN Report, `https://gain.fas.usda.gov/Recent%20GAIN%20Publications/France%20to%20tax%20soft%20drinks.%20U.S.%20Companies%20to%20pay%20the%20most._Paris_France_10-26-2011.pdf`

[7]The indices refer to Metropolitan France only, i.e. they exclude Overseas France

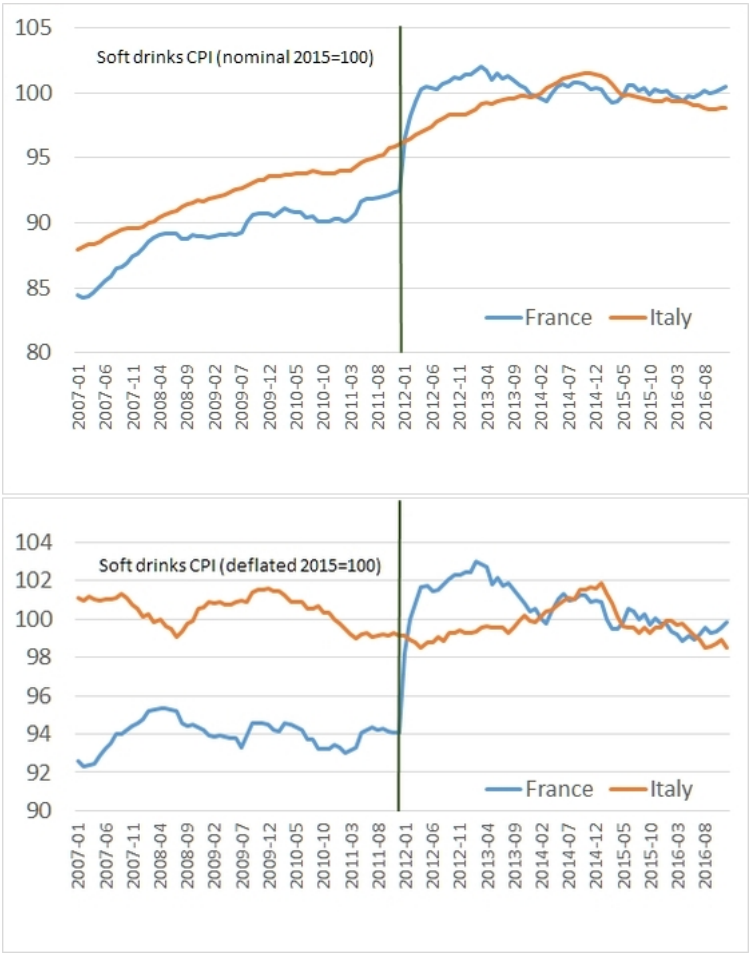

Figure 1: Nominal and real soft drink consumer price indices in France and Italy, 2007-2016 (2015=100)

on a weekly basis, and are observed for the following categories: regular soft-drinks; diet soft-drinks; non-pure fruit juices; mineral water; pure fruit juices; energy and sport drinks. All drinks included in the first three categories are subject to the tax. The regular soft drink category includes flavored mineral waters, also taxed, whereas the mineral water category only includes non-taxed products. Pure fruit juices with no added sugars are also exempt from the tax, whereas the energy and sport drinks category is heterogeneous and may include taxed and non-taxed drinks, depending on whether they contain any sweetener. Household-week observations where the total purchased quantity of drinks was five standard deviations higher than the sample average were dropped for the analysis to control for outliers[8].

[8]This led to discarding only 0.27% of the observations, with a negligible impact on the analysis

The harmonized data-set also include a small set of household characteristics whose definition was comparable between the two national data-sets: household size, presence of children aged under 15, age of the person responsible for food purchases and a binary variable for job status (employed or unemployed). An income variable was not available in the Italian data-set, which provided a scoring system for socio-economic status based on a check-list covering home property, possession of durable goods, education level, car ownership, job position. All Italian households were then classified into five classes depending on their ranking on the above score, with categories defined as follow: (1) top 15%; (2) 65th-85th percentile; (3) 35th-65th percentile; (4) 15th-35th percentile; (5) bottom 15%. We used the same classification, but based on the income variable, for the French households.
Table 1 below shows the difference in the two national samples as reflected by the demographics. The French sample has a larger proportion of households with children aged less than 15, and a higher proportion of those responsible for the food shopping are employed. The percentage of households with a medium-high and high socio-economic status is higher in the two Italian regions relative to their French counterparts. Since the classification of socio-economic status is based on the same percentiles at the country level for France and Italy, this disparity suggest that the two Italian regions are wealthier than the French ones in comparison with the national benchmark, but direct comparability in terms of socio-economic status is not possible. The two samples also differ in terms of age distribution, as the Italian sample has a lower proportion of young households and a higher proportion of households where the person responsible for food shopping is over 55.

Beyond these differences in observable characteristics, the two samples are likely to differ for other unobservable characteristics related to drink consumption. Table 2 shows the average quantities purchased per week by households in France and Italy in 2011 and 2012. The last column is a basic difference-in-difference estimate where the statistical unit is the household-week. This rough estimate ignores the panel structure of the data as well as any heterogeneity across households or time periods (e.g. trends, seasonal effects), and the censored nature of the data because of frequent zero purchases.

4 Methodology

Our estimation of the tax impact on different outcome measures, we exploit the panel structure of the data by estimating Difference-in-Difference (DiD) models which allows for fixed cross-sectional effects and differential fixed time effects. Our general evaluation model is the following:

Table 1. Descriptive statistics: Household demographics, by country.

	Proportion		
	France	Italy	Difference
Presence of children <15 y.o.	0.333	0.230	-0.103***
	(0.471)	(0.421)	(0.025)
Reference person employed	0.714	0.412	-0.302***
	(0.452)	(0.493)	(0.024)
Low SES	0.287	0.183	-0.104***
	(0.452)	(0.386)	(0.024)
Medium-low SES	0.124	0.212	0.089***
	(0.330)	(0.409)	(0.018)
Middle SES	0.416	0.297	-0.118***
	(0.493)	(0.457)	(0.026)
Medium-high SES	0.086	0.193	0.106***
	(0.281)	(0.395)	(0.016)
High SES	0.087	0.115	0.028*
	(0.281)	(0.319)	(0.015)
RP <35 years old	0.221	0.080	-0.141***
	(0.415)	(0.271)	(0.021)
RP 35-44 years old	0.248	0.223	-0.03
	(0.432)	(0.416)	(0.023)
RP 45-54 years old	0.184	0.215	0.03
	(0.388)	(0.411)	(0.021)
RP 55-64 years old	0.163	0.210	0.047**
	(0.370)	(0.408)	(0.020)
RP >64 years old	0.183	0.273	0.090***
	(0.386)	(0.446)	(0.021)
Household size (average)	2.516	2.547	0.031
	(1.143)	(1.053)	(0.060)
		Observations	
N	2928	400	
Liguria		82	
Piemonte-Val D'Aosta		318	
Provence-Alpes- Cote d'Azur	1225		
Rhone Alpes	1703		

Notes: number in brackets are standard deviations for proportions and the standard error of the difference
* p <0.1; ** p <0.05; *** p <0.01;
p-values are obtained from a mean comparison t-test

Table 2. Purchased quantities, weekly averages by country and year (litres per household).

	France		Italy		Diff-in-Diff
	2011	2012	2011	2012	
Regular soft drinks	0.337	0.326	0.620	0.537	+0.072***
	(0.576)	(0.539)	(0.549)	(0.520)	(0.021)
Non-pure juice	0.167	0.164	0.148	0.140	+0.005
	(0.247)	(0.276)	(0.166)	(0.220)	(0.011)
Diet soft drinks	0.111	0.114	0.085	0.064	+0.024
	(0.364)	(0.382)	(0.196)	(0.159)	(0.012)
Pure juice	0.175	0.189	0.036	0.026	+0.024*
	(0.273)	(0.289)	(0.077)	(0.073)	(0.010)
Water	1.102	1.159	3.289	3.377	+0.032
	(1.636)	(1.761)	(2.574)	(2.770)	(0.068)
Energy and sport drinks	0.003	0.004	0.032	0.025	+0.007**
	(0.032)	(0.042)	(0.128)	(0.099)	(0.003)
Taxed drinks	0.615	0.605	0.853	0.741	+0.102***
	(0.767)	(0.763)	(0.651)	(0.653)	(0.029)
Non-taxed drinks	1.278	1.349	3.325	3.403	-0.008
	(1.690)	(1.824)	(2.584)	(2.786)	(0.071)
Total drinks	2.030	2.097	4.415	4.337	+0.145
	(2.050)	(2.186)	(2.916)	(3.137)	(0.087)
N	2958	2958	400	400	3328

Notes: number in brackets are standard deviations for average quantities and the standard error of the diff-in-diff estimator
* p <0.1; ** p <0.05 *** p <0.01

$$Y_{ht} = \gamma_h + \lambda_{0t} + \lambda_{1t} F_{ht} + \delta T_{ht} + \eta_{ht} \quad (1)$$

where Y_{ht} is the outcome observed on unit h at time t; γ_h are cross-sectional fixed effects; $\lambda_0 t$ are fixed time effects for Italian units; $\lambda_1 t$ are fixed quarterly time effects for French units, as $F_{ht} = 1$ if the unit h is French, and 0 if it is Italian; T_{ht} is the DiD interaction term, that is a binary policy variable which assumes a value of 1 only for those units subject to the tax, i.e. French units in 2012, and is 0 otherwise; η_{ht} is a randomly distributed error term. Under the DiD approach, the coefficient δ yields the average treatment effect of the tax on treated units.
The model 1 is applied to the following outcomes:

1. Monthly consumer price indices at the national level
2. Weekly average purchase prices at the regional level
3. Quarterly household-level unit values from the home scan data-set.
4. Weekly average purchased quantities at the regional level
5. Quarterly household-level purchased quantities from the home scan data-set

All models estimated for these outcomes allow for quarterly time fixed effects which are different between Italy and France. The specification of the cross-sectional fixed effects depends on the unit of analysis, as described below.

4.1 Effects on aggregate price indices at National level

A first estimate of the pass-through of the tax to consumer prices is based on the official national consumer price indices. Thus, the DiD model in equation 1 is applied to two national monthly time series, and the specification of the fixed cross-sectional effects reduces to two national intercepts. The model is estimated for each of the three aggregated goods for which data are available, i.e. soft drinks (regular & diet), fruit juices (pure and non-pure), and water.

4.2 Effects on weekly regional consumer prices

In order to explore the pass-through of the tax at the higher level of disaggregation provided by the home scan data, the DiD equation 1 is also applied to the weekly average regional prices. For each of the four regions, the weekly price for each good is computed as the average of the unit value (the ratio between expenditure and quantity) paid by each household that has purchased the good on that week. There is a consolidated literature on unit values (Deaton, 1988; Crawford et al., 2003) that rests on the assumption that households living in

the same geographical area in a given time period face the same price, and any heterogeneity observed at that level stems from different household choices rather than different prices. While this does not rule out that some of the price variation across regions and weeks might also depend on aggregation and quality choices, allowing for fixed regional effects and quarterly time effects controls for these potential sources of heterogeneity. Hence, in our DiD price model, the resulting data-set consists of a panel of four cross-sectional units (the regions) and 104 time periods (one for each week over the two years of our data), and the model specification includes four regional fixed effects.

4.3 Effects on unit values paid by households

Since our level of product aggregation does not allow to explore substitutions within the same product category (e.g. between brands or different product sizes), it is relevant to explore whether households adjust to the tax by choosing cheaper products within the same product group. In other words, households finding a higher price on the supermarket shelves may adjust their consumption basket to pay a lower unit price. Thus, we consider as an additional outcome the unit values paid by households with non-zero purchases in a given quarter. After aggregating expenditures and purchased quantities of each household over a period of 13 weeks (one quarter), the unit values are computed as the ratio between expenditures and purchased quantities. The estimation data set is a panel where each household appears only in quarters with non-zero purchases of the product. Equation 1 is estimated with household-specific fixed effects.

4.4 Effects on quantities purchased by the households

As for unit values, equation 1 is estimated on a household-level panel data-set where the purchased quantities are aggregated for each households over a period of 13 weeks (one quarter). The aggregation over a quarter mitigates the potential "zero bias" associated with stockpiling and heterogeneity in purchase frequencies, but as a measurement unit we refer to the average weekly per capita purchase, for ease of interpretation. In this case, the estimation data-set is a balanced panel that includes all households in each of the eight quarters of 2011 and 2012, including zeroes when the household has not purchased the product in that quarter. The model specification includes household-specific fixed effects.

4.5 Effects on average regional weekly purchased quantities

As an alternative outcome measure, we consider the aggregation on a weekly basis of all households across each of the four region, so that these aggregated impact estimates can be related directly to the estimates of the pass-through

on regional prices. Equation 1 is thus estimated on a region-week panel of observations, with fixed regional effects.

4.6 Effects on heavy purchasers and households with children

We consider two specific policy target groups, to explore the effect of the tax on the quantities purchased and the unit values paid by these households and compare them with those observed on the full sample: (a) households with at least one child aged under 15; (b) heavy purchasers of soft drinks. We define heavy purchasers as those households that within their country lie in the top 25% in terms of per-capita quantity purchased of taxed drinks (soft drinks and non-pure fruit juice) in the year 2011, before the tax was introduced[9]. The 75th percentiles correspond to the purchase of 102.48 litres and 128.38 litres of taxed drinks in France and Italy, respectively.

5 Results

5.1 Impact on prices

Our estimates provide good evidence that the tax on producers and importers has been indeed transferred to the retail prices. The first three column of Table 3 report the estimated impact based on the time series of national consumer price indices considering a different number of years before and after the tax. Because of data constraints, estimates on price indices reduce to three drink categories, one of which is subject to the tax (soft drinks), one is not (mineral and spring water) and the third one (fruit and vegetable juiced) is mixed as only pure juices are exempted from the tax.

We provide a separate set of estimates for nominal and real prices. Potentially different inflation rates are obviously a relevant factor to be accounted for, but the inclusion of differential (quarterly) time effects in equation 1 is expected to capture the effect of unobserved variables following different trends between the two countries, including inflation. Nevertheless, there are clear differences in the two set of estimates, which are consistent with a higher inflation rate in France during the years of the economic crisis, when Italy experienced almost zero inflation or even deflation.

Estimates on the entire 2007-2016 time series, i.e. five years before and after the introduction of the tax, reflect a larger number of observations, but given the longer time span, the relevance of confounding events might be higher. Fur-

[9]We excluded those observations whose purchases were higher than the average plus five standard deviations, to control for any potential outlier bias. However, including these observations bring negligible changes to the results

Table 3. Tax impact on consumer prices, aggregate groups.

	Monthly National CPI[a]			Weekly Regional prices[b]
	2007-2016	2010-2013	2011-2012	2011-2012
Nominal prices				
Soft drinks (Regular & Diet)	0.083***	0.083***	0.092***	0.078***
	(0.002)	(0.003)	(0.004)	(0.001)
Fruit Juice (Pure & Non-pure)	-0.007***	0.009***	0.027***	0.044*
	(0.003)	(0.003)	(0.004)	(0.014)
Water	-0.092***	-0.045***	-0.016***	-0.020***
	(0.002)	(0.003)	(0.002)	(0.001)
Real prices[c]				
Soft drinks (Regular & Diet)	0.057***	0.069***	0.084***	0.071***
	(0.002)	(0.003)	(0.003)	(0.001)
Fruit Juice (Pure & Non-pure)	-0.033***	-0.005*	0.019***	0.036*
	(0.002)	(0.003)	(0.003)	(0.014)
Water	-0.118***	-0.059***	-0.024***	-0.028***
	(0.003)	(0.003)	(0.003)	(0.001)
N	240	96	48	416

Notes:
All impacts are measured in logs, and can be interpreted as % change in price
Data refer to the monthly National Consumer Price Indices, sources: INSEE (France) and ISTAT (Italy)
Weekly average by region from the home scan data-set, sources: Kantar (France) and GfK (Italy)
Real prices are obtained through deflation by the national consumer price index for all items, sources: INSEE (France) and ISTAT (Italy)
* p<0.1; ** p<0.05; *** p<0.01

thermore, as it emerges from Figure 1, the effects of the tax are likely to vary over time, and comparison across different sub-samples might be informative. Thus, we also report estimates from the smaller sample 2010-2013 (two years before and two years after the introduction of the tax). The last sub-set refers to the shorter period 2011-12 (one year before and one year after the tax). While drastically reducing the number of observations these estimates are comparable with those obtained from home scan data, which refers to the same period.
Overall, there is clear evidence of a significant price increase for the taxed group of soft drinks. The estimates on nominal prices ranges between a +8.3% for the longer sub-sets and a +9.2% on the 2011-2012 sub-sets. When price indices are deflated by the overall national consumer price index, the estimated impact is smaller, but still highly significant and consistent with the tax rate. On the 2010-13 sub-sample, the real increase is estimated at 6.9%, and in the shorter 2011-12 time window it rises to 8.4%, only slightly lower than the nominal price estimate. As a back-of-the-envelope computation, the average price of sodas (regular and diet) in France in 2011 as estimated by the home scan data was €1.05, so that a 8.4% real increase correspond to €0.088. Our estimates are consistent with a full transmission, and are even suggestive of a slight over-transmission, as envisaged by previous studies.
When we look at the other drink categories, the "mixed" fruit juice group returns a small but significant price reduction when the 2007-2016 period is considered, whereas a small but positive and significant price change is detected when the smallest sample is taken into account. On the 2011-12 sample, the estimated real effect is +2.7%. Finally, estimates on the water category consistently return evidence on a price reduction, which is quite large when considering the full CPI sample and the real CPI data (-11.8%) and progressively reduce to -2.4% when observations are restricted to the 2011-12 sample.
The last column of Table 1 provides an interesting comparison on the 2011-12 sample, as the home scan data are collected from different and independent data sources, and refer to weekly regional average prices as computed from the unit prices paid by the households in the French and Italian home scan panels. The estimates are very consistent with those from the CPI over the same period, and suggest a real price increase for the sodas category which is perfectly in line with the tax level (on average €0.075). Similarly, the home scan estimates suggest a smaller increase for the partially taxed juice category (+3.6%) and, again, a small but significant decrease in the price of mineral water (-2.8%).

As the home scan data allow a higher level of disaggregation, Table 4 reports the estimated tax effects based on the weekly time series of regional prices. Once more, our estimates confirm price transmission for the targeted drinks, with the largest increase observed for diet drinks (+9.6% in real terms, about €0.089

Table 4. Tax impact on average weekly regional prices by drink product (2011-2012).

	Nominal	Deflated[a]
Regular soft drinks	0.075***	0.068***
	(0.001)	(0.001)
Diet soft drinks	0.104***	0.096***
	(0.012)	(0.012)
Non-pure fruit juice	0.045**	0.038**
	(0.010)	(0.010)
Pure fruit juice	0.034*	0.026
	(0.013)	(0.013)
Energy drinks	0.055	0.047
	(0.132)	(0.132)
Water	-0.024***	-0.028***
	(0.003)	(0.001)
N	416	416

Notes:
All impacts are measured in logs, and can be interpreted as % change in price
Data are weekly averages by region from the home scan data-set, sources: Kantar (France) and GfK (Italy)
[a] Real prices are obtained through deflation by the national consumer price index for all items, sources: INSEE (France) and ISTAT (Italy)
* p<0.1; ** p<0.05; *** p<0.01

Table 5. Impact on weekly per-capita purchased quantities and purchase unit values.

	Purchased quantities			Unit values	Prices
	Household[a]	Region[b]		Household[a]	Region[b]
	Litres/week	*Litres/week*	*Logs*	*Logs*	*Logs*
Soft drinks (Regular & Diet)	-0.018	-0.046***	-0.153***	0.093***	0.078***
	(0.013)	(0.001)	(0.004)	(0.011)	(0.001)
Fruit Juice (Pure & Non-pure)	-0.029***	-0.044***	-0.151***	0.049***	0.044*
	(0.009)	(0.007)	(0.022)	(0.008)	(0.014)
Water	0.023	-0.042	-0.061	0.006	-0.020***
	(0.032)	(0.035)	(0.043)	(0.013)	(0.001)
Regular soft drinks	-0.017	-0.032***	-0.144***	0.092***	0.075***
	(0.010)	(0.002)	(0.010)	(0.013)	(0.001)
Diet soft drinks	-0.001	-0.014***	-0.180***	0.072***	0.104***
	(0.009)	(0.001)	(0.006)	(0.018)	(0.012)
Non-pure fruit juice	-0.024***	-0.032***	-0.229***	0.067***	0.045**
	(0.006)	(0.005)	(0.035)	(0.011)	(0.010)
Pure fruit juice	-0.005	-0.012***	-0.082***	0.033***	0.034*
	(0.006)	(0.001)	(0.010)	(0.008)	(0.013)
Energy drinks	-0.001	-0.001	-0.315*	-0.069	0.055
	(0.000)	(0.000)	(0.127)	(0.050)	(0.132)
N	24,467	416	416	1767-19982	416

Notes:
[a] Quarterly aggregation at the household level, sources: Kantar (France) and GfK (Italy)
[b] Weekly average by region from the home scan data-set, sources: Kantar (France) and GfK (Italy)
* p<0.1; ** p<0.05; *** p<0.01

considering the average price of €0.93 for diet drinks, and a +7.5% for regular soft drinks (about €0.074). The evidence on the pass-through is also supported by the estimates on fruit juice prices, as we find a significant real price increase in non-pure juices real prices (+3.8% or €0.048), and no significant (real) impact on pure fruit juice. The energy drinks category, which is very heterogeneous and includes both taxed and non-taxed drinks depending on the presence of added sugars, does not result in significant impact estimates.

5.2 Impact on purchased quantities and unit values

The application of the Difference-in-Difference model to price data consistently confirms that the tax has been fully transmitted to market prices, at least for regular and diet soft drinks, slightly less for non-pure fruit juices. As a next step we explore whether (a) consumers have on average adjusted their purchased quantities; (b) whether they have adjusted the composition of their drink basket in response to the average price increase, so that the paid unit price may be

different from the actual shelf price.
The first column of table 5 reports the estimated effect of the tax on the average quantity purchased by each household. The unit of analysis is the quarterly amount purchased by each household, a time frequency which mitigates the potential issues associated with heterogeneity in frequency of purchases and stockpiling[10].
As described in Section 4 we also explore the aggregate impact on weekly regional consumption. While we lose information about the household heterogeneity, this level of aggregation is fully consistent with our estimates on prices, and is not affected by any issue related to zero purchases, so that the model can also be estimated in logarithms, hence returning the per cent change in consumption.
When we look at the household-level model, there is modest evidence on the tax effects. The signs are consistent with expectations, and indicate a small reduction in the average purchases of sodas (about 18 millilitres per capita per week) and juices (29 millilitres per week), and an increase in water (23 millilitres per week). However, only the effect on (non-pure) fruit juices results as significant. Considering the second column and the aggregate regional weekly model, the size of the effects is larger and becomes significant. Regional purchases of soft drinks decrease by about 46 millilitres per capita per week, which corresponds to an average reduction of 15.3%. Averages purchases of juices are also affected by the tax to a similar extent (-44 millilitres or -15.1%), and the negative value for water is non-significant. Among sodas, the largest reduction in absolute terms concerns regular soft drinks and non-pure fruit juices, whose purchases fall by about 32 millilitres per capita per week, whereas purchases diet soft drinks decrease by 18 millilitres. The model also suggest a significant, but smaller, reduction for pure fruit juice (12 millilitres). These apparently small average changes when the population at large (including non-purchasers) is considered are actually important when considered in log (percentage) terms, as the reductions are 22.9%, 18% and 14.4% for non-pure fruit juices, diet soft drinks and regular soft drinks, respectively.
The last two column add some information about potential adjustments of household choices in response to the price change. By comparing the column reporting the impact in term of unit values with the last column (the market price impact), we find no evidence of reallocations resulting in relatively lower purchase prices. On the contrary, the price increase experienced by purchasers result higher than the estimated tax impact on prices, with the only exception of diet drinks, whose change in unit prices (+7.2%) is slightly lower than the estimated change in market prices (+10.4%).

[10]For ease of interpretation the measurement unit is per-capita weekly consumption in litres

Table 6. Impact on weekly per-capita purchased quantities and purchase unit values, households with children only.

	Purchased quantities			Unit values
	Household[a]	Region[b]		Household[a]
	Litres/week	*Litres/week*	*Logs*	*Logs*
Soft drinks (Regular & Diet)	-0.072**	-0.041***	-0.160***	0.117***
	(0.033)	(0.002)	(0.008)	(0.019)
Fruit Juice (Pure & Non-pure)	-0.055***	-0.047***	-0.167***	0.050***
	(0.021)	(0.004)	(0.015)	(0.013)
Water	-0.105*	-0.073**	-0.131**	-0.006
	(0.063)	(0.020)	(0.040)	(0.023)
Regular soft drinks	-0.026	-0.022***	-0.119***	0.108***
	(0.027)	(0.001)	(0.001)	(0.021)
Diet soft drinks	-0.046***	-0.018**	-0.296***	0.107***
	(0.017)	(0.004)	(0.042)	(0.029)
Non-pure fruit juice	-0.059***	-0.035***	-0.254***	0.065***
	(0.018)	(0.000)	(0.022)	(0.017)
Pure fruit juice	0.004	-0.013*	-0.085**	0.025*
	(0.013)	(0.004)	(0.017)	(0.013)
Energy drinks	-0.002*	-0.001	-0.356	-0.088
	(0.001)	(0.001)	(0.305)	(0.076)
N	3011	416	416	750-1062

Notes:
[a] Quarterly aggregation at the household level, sources: Kantar (France) and GfK (Italy)
[b] Weekly average by region from the home scan data-set, sources: Kantar (France) and GfK (Italy)
* p<0.1; ** p<0.05; *** p<0.01

We look for further evidence that the tax is effective in reducing consumption by considering two especially relevant population sub-groups, households with children and households characterised by 'heavy purchases' of the taxed drinks, defined as those in the top quartile in terms of yearly consumption in 2011.

The impact estimates consolidate our findings on the overall sample. Considering the effect on households with children in Table 6, the significance and the extent of the per-capita reductions is higher, and estimates at the household level also return consistent evidence on the tax impact. The reduction in soft drink purchases amount at 72 millilitres per capita per week, against 55 for fruit juices. The largest effect is observed on non-pure fruit juices (-55 millilitres) and diet soft drinks (-46 millilitres). The household-level model also returns an unexpected impact on water purchases (-102 millilitres), although only significant at the 10% level. When these estimates are compared to those from the model on weekly regional data (the aggregation across households with children on a weekly basis) the impact are slightly different, but consistent and more significant. The fact that the weekly aggregate model returns more efficient estimates is not surprising if one consider the number of fixed effects to be included. Again, we find that household with children aged less than 15 reduce in a significant way their purchases of soft drinks (41 milliliters or 16%), as a result of a decrease in the purchases of regular soft drinks (22 millilitres or 11.9%) and diet soft drinks (18 millilitres or 29.6%). The significant reduction in purchases of fruit juices (-47 millilitres or -16.7%) is mainly driven by the lower consumption of their taxed component, non-pure fruit juice, whose purchases fall by 35 millilitres (or 25.4%), whereas there is only a small and hardly significant reduction in purchases of pure fruit juice (-13 millilitres or -8.5%). Once more we also find a less expected reduction in water purchases. On the other hand, the analysis on the unit values paid by the households confirms again that these households have indeed experienced the price increase, and did not respond to the tax by substituting the taxed drinks with cheaper alternatives.

Table 7 completes our analysis on the impact on quantities and unit values by showing the effects of the tax on the households with the highest consumption of soft drinks. The results are striking and go in the direction of the correct identification of the tax effects. These households are indeed those responding more in terms of purchases, as one would expect since the relevance of the drinks to their budget is higher relative to other households. The reduction in the purchased quantity of soft drinks is estimated at 159 millilitres per capita per week, slightly less than one can of soft drinks every two weeks. The estimate based on aggregated weekly regional data is even higher (173 millilitres), a reduction of 25.3% relative to the pre-tax purchases. The reduction in the purchases of regular soft drinks and diet soft drinks is estimated consistently by

Table 7. Impact on weekly per-capita purchased quantities and purchase unit values, heavy purchasers only.

	Purchased quantities			Unit values
	Household[a]	Region[b]		Household[a]
	Litres/week	*Litres/week*	*Logs*	*Logs*
Soft drinks (Regular & Diet)	-0.159***	-0.173***	-0.253***	0.108***
	(0.039)	(0.019)	(0.028)	(0.016)
Fruit Juice (Pure & Non-pure)	-0.098***	-0.093***	-0.235***	0.061***
	(0.018)	(0.014)	(0.020)	(0.014)
Water	-0.074	-0.105	-0.127	0.021
	(0.059)	(0.050)	(0.071)	(0.027)
Regular soft drinks	-0.116***	-0.117***	-0.236***	0.125***
	(0.030)	(0.012)	(0.028)	(0.018)
Diet soft drinks	-0.043*	-0.056***	-0.312***	0.074***
	(0.026)	(0.008)	(0.031)	(0.028)
Non-pure fruit juice	-0.087***	-0.076***	-0.318***	0.059***
	(0.014)	(0.008)	(0.002)	(0.017)
Pure fruit juice	-0.011	-0.017*	-0.115**	0.035**
	(0.013)	(0.006)	(0.034)	(0.016)
Energy drinks	-0.003***	-0.003***	-0.712***	-0.074
	(0.001)	(0.000)	(0.076)	(0.076)
N	6455	416	416	3020-6194

Notes:
[a] Quarterly aggregation at the household level, sources: Kantar (France) and GfK (Italy)
[b] Weekly average by region from the home scan data-set, sources: Kantar (France) and GfK (Italy)
* p<0.1; ** p<0.05; *** p<0.01

the two models. Heavy consuming households reduce their purchases by about a can of regular soft drinks every three weeks (-23.6%), and diet soft drinks are also reduced (between 43 and 56 millilitres depending on the model, or -31.2%). The reduction is also large for non-pure fruit juice (between 76 and 87 millimetres, -31.8%). The estimated effect on water is not significant, and also for pure fruit juice is very small (between 11 and 17 millimetres) and only significant in the regional model.
Finally, the increase in unit prices paid by heavy purchasing household is large and significant for all taxed drinks, ranging between +5.9% for non-pure fruit juices and +12.5% for regular soft drinks. Our quasi-experimental analysis provides good evidence that these household have actually faced higher costs and have significantly reduced their consumption in the first year of the tax.

6 Conclusion

The ultimate impact of a soda tax is subject to many elements of uncertainty related to price transmission, firm strategic behaviors and consumer response and substitution patterns. The existing evidence on this type of measure rests primarily on simulations, but recently there have been several policies that could be evaluated after their implementation. One challenge in these ex post evaluations is the consideration of pre-existing trends and confounding effect, or - under a scientific perspective - the lack of an appropriate control group.
In our assessment of the 2012 French soda tax we address this challenge by referring to a natural control group for French households that were exposed to the introduction of a tax on sweetened soft drinks starting from January 2012. By looking at two regions in France and two neighbouring Italian regions across the border before and after the tax, we open the way to a difference-in-difference estimation of the tax impact. The availability of panel data on home purchases allows to control for household heterogeneity and non-linear time trends via a fixed effect specification. Under this specification, we have estimated the tax impact on market prices, unit values, and purchased quantities.
We provide evidence that the tax - which is applied to producers and importers - has been fully transmitted to consumer prices for all taxed drinks. Furthermore, the consumer costs associated with this price increase have not been mitigated by substitutions towards products with lower unit prices, but it has generated a significant decrease in purchases.
When considering at the full sample of households, the reduction of purchased quantities for taxed goods may seem small in size, less than 80 millilitres per capita per week altogether for regular and diet soft drinks and non pure fruit juice. Still, this value means more than 15% of average consumption.
Not only, but when we focus on smaller sub-sets of the sample, consisting of

households with children and - especially - households with the highest consumption levels, the evidence that the tax has indeed generated a substantial reduction in purchases becomes more compelling. Our estimate suggest that the reduction in purchases of taxed drinks for households in the top consumption quartile might be as large as one litre per capita per month, which corresponds to more than 25% of the pre-tax purchase levels.

Suggestive evidence of the (over-)transmission of the French tax to the market prices had been provided by previous studies (Berardi et al., 2016; Bonnet and Réquillart, 2013) and our ex-post evidence confirm these findings. We also show that the tax has resulted in significantly lower consumption of the taxed good in the first year of implementation.

Our data do not allow inference on the longer term effects of the tax, and even with a longer time series it would become difficult to assume that the difference-in-difference model can isolate the tax effect from other confounding factors intervening in the four regions. A further limitation in our study design must be acknowledged, as our data only cover drinks purchased for home consumption, but out-of-home consumption behavior are likely to be very relevant to assess the ultimate weight or health outcome of the tax. Still, our quasi-experimental setting can be compared to other recent ex-post evaluations on similar fiscal measures in Mexico, Hungary and the city-level tax in Berkeley. Evaluations of these taxes found a complete pass-through and significant reduction in purchases which ranges between 7% and 20%, and our results reinforce the idea that soda taxes may have a meaningful impact on purchases.

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