The impact of the French soda tax on prices, purchases and tastes: an ex post evaluation

Sara Capacci[1], Olivier Allais[2], Celine Bonnet[3], and Mario Mazzocchi[4]

[1]Department of Economics, University of Bologna
[2]INRA, UR1303 ALISS
[3]Toulouse School of Economics (INRA, GREMAQ)
[4]Department of Statistical Sciences, University of Bologna

(Very) Preliminary draft 15 April 2016 - Please do not quote

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 time effects to estimate the impact of the tax on average prices paid by consumers and purchased quantities for a set of non-alcoholic drink categories. We also explore whether the policy is consistent with a change in consumer tastes, intended as average demand when prices and total drink expenditure are held constant. Our results suggest a relatively small impact of the tax on prices with an uneven pass-through across the various drink categories. Consequently, estimated response of purchased quantities is also small, and not entirely consistent with the size of the price change. Results also suggest that the tax has reduced purchases of regular soft drinks even in absence of a price effect, while purchases of diet drinks (which are taxed) have increased despite some evidence of a price increase following the tax. These and other results are consistent with our estimates of the taste effect of the tax, and may suggest that the labeling effect of soda taxes might have a broader reach than the taxes themselves.

JEL classification: I18, D12

Keywords: Soda tax, Difference in Difference, Policy Evaluation

Acknowledgments: The preparation of this paper was supported by the DEterminants of DIet and Physical ACtivity (DEDIPAC) knowledge hub. This work is supported by the Joint Programming Initiative 'Healthy Diet for a Healthy Life'. The funding agencies supporting this work are the Institut National de la Recherche Agronomique (INRA) for France and the Ministry of Education, University and Research for Italy.

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 evidence on the effectiveness of these taxes is still scarce. In this study, we evaluate the impact of the tax on sweetened non-alcoholic drinks introduced in France in January 2012.

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[1].

Despite the growing spread of fiscal measures across the World, the evidence base is still incomplete and in some cases conflicting, not least because they 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 whose estimates depend heavily on the demand model specification (Cornelsen et al., 2016) and the variability in price data relative to the tax level.

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[2], 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, several governments 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 (Cochero et al., 2017).

In Europe, according to the Nourishing data-base[3], 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

[1]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

[2]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

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

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 €0.07 per liter. It applies to all sweetened drinks, including sugar substitutes used in diet drinks.

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, and even over-transmit, cost changes or excise taxes to consumers.

In this study, we evaluate the impact of the French soda tax on three different outcome measures: (a) prices paid by purchasers; (b) purchased quantities; (c) consumer tastes, intended as average demand share when prices and total expenditure are held constant. 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.

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 7.55 cents per liter. The tax is paid by manufacturers and processors in France and by French importers.

In its initial proposal[4], 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. 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[5]. 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

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 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[6].

[4]Projet de loi de finances pour 2012, 28 September 2011.

[5]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

[6]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. There is no evidence of a tax effect, and significant values have the opposite sign, suggesting an increase in purchases of taxed drinks in France, relative to Italy over the same period.

4 Methodology

We exploit the panel structure of the data by estimating Difference-in-Difference (DiD) models allowing for fixed effects, and accounting for the censored nature

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

of the data. Our baseline model is the following:

$$Y_{ht} = \gamma_h + \lambda_t + \delta T_{ht} + \eta_{ht} \tag{1}$$

where Y_{ht} is the outcome observed on household h at time t; γ_h are fixed household effects; λ_t are fixed time effects; T_{ht} is the DiD interaction term, that is a binary policy variable which assumes a value of 1 only for those household subject to the tax, i.e. French households 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 household exposed to it.

4.1 Impact on prices

Our first objective is to explore whether our data captures an impact on prices paid by the households. Our data-set provides information on household expenditures and purchased quantities for aggregate categories. Their ratio represents the unit value paid by the household and depends on the actual retail price, but also on a number of other factors related the choice of different brands, package sizes, quality, retail outlet. Thus, the heterogeneity in unit values across households and over time does not only reflect price variations, but also different consumer choices. This distinction becomes particularly relevant when looking at the effect of a tax, as consumers tend to adjust their quality (hence unit values) downwards when prices go up.

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. Based on this assumption, the weekly average unit values by region are the outcome variable Y_{ht} in equation (1). 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 time effects controls for these potential sources of heterogeneity. Hence, in our DiD price model, γ_h is constant across households living in the same region, and λ_t capture monthly variations in prices that are common to the four regions.

4.2 Impact on purchased quantities

The impact of the tax on purchased quantities is also estimated through equation (1), but a correction is necessary because of the large proportion of zero observations associated with non-purchases. A standard Heckman two-step procedure was adopted to estimate the unconditional impact of the tax and mitigate the censoring bias. In the first step, the probability of non-zero purchase was modeled through the following probit equation:

$$f_{ht} = \alpha + B\mathbf{Z_h} + \tau_1 \log x_{ht} + \tau_2 \log x_{ht}^2 + R\mathbf{S_h} + \omega_{ht} \tag{2}$$

Where f_{ht} is a dummy variable which takes on the value 1 when the i-*th* household purchases the good in question in week t and zero otherwise, $\mathbf{Z_h}$ is a set of household characteristics (age and employment status of the head of the household, socio-economic status, presence of children under 15, household size and region), x_{ht} is the household total expenditure on drinks in week t, $\mathbf{S_h}$ is a set of 13 4-week seasonal dummies and ω_{ht} is a random error term. Based on the coefficient estimates from equation (2), the Inverse Mills Ratio IMR_{ht} is computed for each observation as:

$$IMR_{ht} = \frac{\phi(f_{ht}^*)}{\Phi(f_{ht}^*)} \tag{3}$$

where f_{ht}^* are predictions from the probit model (2), ϕ is the standard normal density function and Φ is the cumulative distribution function. In the second estimation step, the DiD equation is augmented as follows:

$$Y_{ht} = \gamma_h + \lambda_t + \delta T_{ht} + \kappa IMR_{ht} + \eta_{ht} \qquad \text{with } Y_{ht} > 0 \tag{4}$$

where Y_{ht} is the per-capita quantity purchased by the h-th household on week t, γ_h are fixed household effects, λ_t are fixed (weekly) time effects, and only non-zero observations enter the estimation sample. The impact of the tax on weekly purchased quantities is captured by the δ coefficient.

4.3 Impact on tastes and labeling effect

Our hypothesis is that the tax may not only act on purchased quantities through price effects, but it also affect consumer demand through an information (labeling) effect. Such labeling effect derives from the information that is transferred to consumers when a good is taxed (or not) under a health promotion rationale, and may be particularly important if the fiscal measure is new and receives media attention. In other words, if a soda tax is imposed and communicated as a measure to reduce consumption of unhealthy drinks, consumer may demand less of these goods even if the tax is not (fully) transferred from producers to consumers. Consumer move along the demand curve because of the price effect, and the demand curve shifts leftwards because of the labeling effect, so that the total effect on purchased quantities is a combination of these two effects. Similarly, after the introduction of the tax on drinks with added sugars and sweeteners a drink is not taxed (e.g. pure fruit juices), this could be perceived as positive labeling, and the demand curve for this good shifts rightwards.

The literature on labeling effects dates back to Thaler (1990) and refers to the mental accounting which drives consumers in their budget allocation when in-

come sources are labeled. Contrarily to the standard economic assumption that income has no label and that consumers allocate their total budget based on their preferences and independently from the income sources, empirical evidence has shown that behaviors are indeed influenced by policy labels, for example that households that receive child benefits spend the money on children (Kooreman, 2000) and winter fuel payments are spent on the gas bill (Beatty et al., 2014) even in absence of legal constraints requiring to do so. Similarly, a behavioral change may be induced by the soda tax even in absence of a change in the retail price, simply because the consumer knows that part of the soda price is aimed at discouraging consumption. A parallel way to interpret demand shifts after a tax is a different perception of the product characteristics induced by the media coverage of the fiscal measure.
Thus, our objective is to estimate the change in demand induced by the tax when prices and total expenditure are held constant. Drawing from Atkin (2013), tastes are defined as a latent stock variable that changes the budget share of a good, ceteris paribus, and we model them as shifters of the intercept in an Almost Ideal Demand System that includes demographic variables beyond the usual price and expenditure terms. Within Atkin's specification, regional tastes are captured by a set of regional dummies. In our specification we allow for demographics, monthly time effects (that also embody seasonal patterns), and a fixed country effect allowing for different tastes between French and Italian households. An additional interaction term, similarly to the DiD model (1) captures any change in taste gap between France and Italy ascribed to the introduction of the tax, after controlling for demographic differences, country differences and fixed time effect. The structural system we estimate is the following augmented AIDS model (Deaton and Muellbauer, 1980):

$$w_{iht} = \alpha_i + \Theta_i \mathbf{Z_h} + \kappa_i F_h + \lambda_{it} + \delta_i T_{ht} + \sum_{g=1}^{n} \gamma_{ig} \log p_{ght} + \beta_i \log(\frac{x_{ht}}{P_{ht}}) + \epsilon_{iht} \quad (5)$$

where $i = 1, ..., n$ is the index for each of the n goods in the system, w_{iht} is the expenditure share of good i for household h at time t, $\mathbf{Z_h}$ is a set of fixed household characteristics of household h, F_h is a binary variable which is 1 for French households and 0 for Italian households, λ_{it} is the fixed time effect for the i-th equation, p_{ght} is the price of good g faced by household h at time t, where prices are - as before - the weekly averages of unit values by region, x_{ht} is the total expenditure on drinks borne by household h at time t and P is the standard non-linear price index of the AIDS model. The coefficients of the n simultaneous equations are constrained to meet the adding-up, symmetry and homogeneity theoretical requirements, i.e. $\gamma_i g = \gamma_{gi}$, $\sum_{i=1}^{n} \alpha_i = 1$, $\sum_{i=1}^{n} \Theta_i = 0$, $\sum_{i=1}^{n} \kappa_i = 0$, $\sum_{i=1}^{n} \lambda_{it} = 0$, $\sum_{i=1}^{n} \delta_i = 0$, $\sum_{i=1}^{n} \gamma_{ig} = \gamma_{hi} = 0$, $\sum_{i=1}^{n} \beta_i = 0$. As for the DiD model on purchased quantities, expenditure share data are censored at 0, and ignoring such censoring may lead to biased estimates. The standard Heckman approach is problematic with systemwise estimation, as it involves discarding all observations where any of the expenditure share is zero, hence we rely on the alternative formulation described in Shonkwiler and Yen (1999) and Tauchmann (2005), that makes use of the full estimation sample and is common in the empirical literature. As in the Heckman model, the first step consist in estimating a probit equation, in our case the same we had defined in equation (2) as non-zero quantities generate non-zero expenditure shares. For the second step, we compute again the probabilities from the standard normal density function $\phi(f^*_{iht})$ and the cumulative distribution function $\Phi(f^*_{iht})$, where f^*_{iht} are the predictions from the probit model. These estimates enter the second estimation step as follows:

$$w_{iht} = \phi(f^*_{iht})m_{iht} + \theta_i\Phi_(z^*_{iht}) \tag{6}$$

where m_{iht} is the right-hand side expression in the AIDS model (5) for good i, household h and time t. While the adding-up, symmetry and homogeneity conditions are imposed within the AIDS model m_{iht}, equation 6 does not automatically satisfy the adding-up condition, the full system of equations is non-singular and is estimated by feasible generalized nonlinear least squares.

5 Results

Table 3 reports the estimated tax effect on average purchase prices, quantities and consumers tastes. Based on our identification strategy, our estimates suggest that the tax has not been fully transferred to the taxed goods over the first twelve months of implementation. More specifically, relative to the 7.2 euro-cent per liter excise tax, we find no significant price effect for the regular soft drink category, as opposed to a relatively large and significant effect for non-pure fruit juice (about 19 euro-cent per liter) and diet soft drinks (about 16 euro-cent per liter). Although our analysis is only based on purchase prices and we do not have information on producer prices, this result might suggest that those companies with multiple products and brands may have redistributed their tax burden towards those drinks containing fruit or artificial sweeteners that are perceived as healthier, to safeguard sales for other regular soft drinks that are more likely to be damaged by the labeling effect of the tax. On average, also considering the different relative weight of the various drink categories in household budgets, the price of taxed drinks has increased by 3.5 euro-cent in the French regions relative to the Italian counterparts, following the introduction of the tax. As expected, no significant impact on prices is detected for non-taxed goods. Considering the different categorization of drinks, and a

Table 3. Estimated impact on average prices, purchased quantities and tastes, by drink category .

	Prices €/ liter	Purchased Quantities liters / week	Tastes Δw_i
Regular soft drinks	0.003	-0.083***	-0.174***
	(0.024)	(0.023)	(0.025)
Non-pure juice	0.195***	-0.040**	-0.263***
	(0.055)	(0.017)	(0.027)
Diet soft drinks	0.165***	0.023	-0.023
	(0.055)	(0.063)	(0.018)
Pure juice	0.039	0.028*	0.069***
	(0.052)	(0.014)	(0.016)
Water	0.001	0.109*	0.237***
	(0.006)	(0.065)	(0.067)
Energy and sport drinks	-0.132	0.163	0.153***
	(0.218)	(0.103)	(0.022)
Taxed drinks	0.035*	-0.093***	-0.456***
	(0.020)	(0.021)	(0.052)
Non-taxed drinks	0.009	0.057	0.306***
	(0.006)	(0.052)	(0.059)

Notes: Clustered standard errors in brackets, errors are clustered by week
* p <0.1; ** p <0.05 *** p <0.01

slightly longer time span, our finding on price effects are consistent with those shown in Berardi et al. (2016).

The second column shows the estimated impact of the tax on purchased quantities. Interestingly, the response on purchased quantities is only loosely related to the price effects. We find a small but significant decrease in purchases of regular soft drinks (about 8 centiliters per person per week, about a can per month), a smaller but still significant reduction in non-pure fruit juices, no impact on diet drinks, and a significant increase (at the 10% level) for pure fruit juices and water. On aggregate, the average reduction in taxed drinks is significant and estimated in 9 centiliters per person per week, whereas the increase on the aggregate non-taxed drinks is not significant.

The final column, which reports the estimate impact on tastes, i.e. the δ coefficient in equation (5) provides a suggestive explanation that is consistent with our findings. The signaling effect of the tax has shifted demand away from all taxed drinks except diet soft drinks, and a positive effect on demand for non-taxed drinks.

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.

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 neighboring 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 purchase prices, purchased quantities and tastes, where the latter are defined as changes in the budget shares after controlling for demographics, fixed time effects, country effects, and price and expenditure levels.

Our estimate of the impact on purchase prices suggests some heterogeneity in the distribution of the tax on the sub-categories of taxed drinks. We find a relatively large impact on the price of non-pure fruit juices (19 euro-cent per liter) and diet sodas (16 euro-cent) per liter, but no significant impact on regular soft drinks. When comparing our findings with those provided in Berardi et al. (2016) we must consider the different type of data, as we rely on purchase prices for home shopping rather than supermarket prices, a different approach to estimation, different categorization and a different time span, but our estimates seem to be consistent with the average pass-through of 7-8 euro-cents that they find for the soda group six months after the introduction of the tax.

Based on our identification strategy, we do find some consumption response to the tax, and our results indicate a reduction in purchased quantities of regular soft drinks and non-pure fruit juices, but no impact on diet drinks. Although these responses seem to be conflicting with the evidence on prices, our further analysis on the impact of tastes indicates that they are consistent with a signaling effect of the tax. On average, the total reduction of purchased quantities of taxed drinks is around 9 centiliters per week per person, i.e. around a standard soda can per month.

Various limitations in our study design must be acknowledged. First, 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. Second, in order to identify the impact we need to

assume common fixed time effects across the four regions. Allowing for differential time effects undermines the identification of the difference-in-difference estimator.
Additional estimates on population sub-groups (heavy consumers, household with children) will provide further evidence on the robustness of our findings.

References

Atkin, D. (2013). Trade, tastes, and nutrition in india. *The American Economic Review*, 103(5):1629–1663.

Beatty, T. K., Blow, L., Crossley, T. F., and O'Dea, C. (2014). Cash by any other name? evidence on labeling from the uk winter fuel payment. *Journal of Public Economics*, 118:86–96.

Berardi, N., Sevestre, P., Tépaut, M., and Vigneron, A. (2016). The impact of a 'soda tax'on prices: evidence from french micro data. *Applied Economics*, 48(41):3976–3994.

Bonnet, C. and Réquillart, V. (2013). Impact of cost shocks on consumer prices in vertically-related markets: the case of the french soft drink market. *American Journal of Agricultural Economics*, page aat055.

Briggs, A. D., Mytton, O. T., Kehlbacher, A., Tiffin, R., Rayner, M., and Scarborough, P. (2013). Overall and income specific effect on prevalence of overweight and obesity of 20% sugar sweetened drink tax in uk: econometric and comparative risk assessment modelling study. *Bmj*, 347:f6189.

Cochero, M. A., Rivera-Dommarco, J., Popkin, B. M., and Ng, S. W. (2017). In mexico, evidence of sustained consumer response two years after implementing a sugar-sweetened beverage tax. *Health Affairs*, pages 10–1377.

Cornelsen, L., Mazzocchi, M., Green, R., Dangour, A. D., and Smith, R. D. (2016). Estimating the relationship between food prices and food consumption—methods matter. *Applied Economic Perspectives and Policy*, page ppw010.

Crawford, I., Laisney, F., and Preston, I. (2003). Estimation of household demand systems with theoretically compatible engel curves and unit value specifications. *Journal of Econometrics*, 114(2):221–241.

Deaton, A. (1988). Quality, quantity, and spatial variation of price. *The American Economic Review*, pages 418–430.

Deaton, A. and Muellbauer, J. (1980). An almost ideal demand system. *The American economic review*, 70(3):312–326.

Fletcher, J. M., Frisvold, D., and Tefft, N. (2010). Can soft drink taxes reduce population weight? *Contemporary Economic Policy*, 28(1):23–35.

Guerrero-López, C. M., Unar-Munguía, M., and Colchero, M. A. (2017). Price elasticity of the demand for soft drinks, other sugar-sweetened beverages and energy dense food in chile. *BMC Public Health*, 17(1):180.

Kooreman, P. (2000). The labeling effect of a child benefit system. *The American Economic Review*, 90(3):571–583.

Mytton, O. T., Clarke, D., and Rayner, M. (2012). Taxing unhealthy food and drinks to improve health. *BMJ*, 344(may15 2):e2931–e2931.

Paarlberg, R., Micha, R., and Mozaffarian, D. (2017). Can local soda taxes continue to spread? *Food Policy*, forthcoming.

Shonkwiler, J. S. and Yen, S. T. (1999). Two-step estimation of a censored system of equations. *American Journal of Agricultural Economics*, 81(4):972–982.

Tauchmann, H. (2005). Efficiency of two-step estimators for censored systems of equations: Shonkwiler and yen reconsidered. *Applied Economics*, 37(4):367–374.

Thaler, R. H. (1990). Anomalies: Saving, fungibility, and mental accounts. *The Journal of Economic Perspectives*, 4(1):193–205.