Does a Spoonful of Sugar Levy Help the Calories Go Down? An Analysis of the UK Soft Drinks Industry Levy

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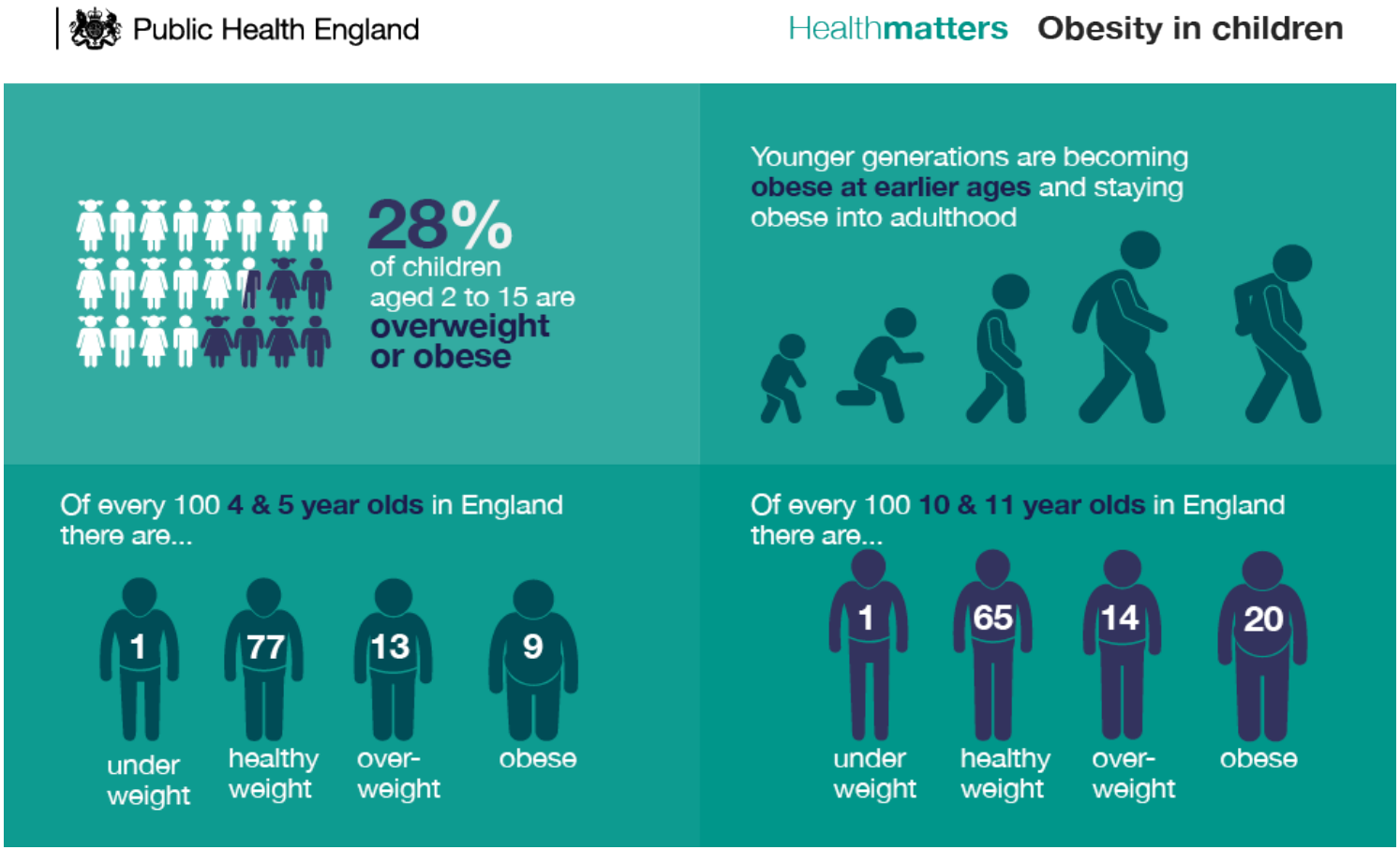
American Economic Association Annual Meeting
HERO Session, 8 January 2023

Obesity in the UK

About two thirds of adults are overweight or obese



Our Study

Clever tax-design: In March 2016 UK Government announced a levy of £0.29 per litre (incl. VAT) on high-sugar SSBs to be enacted in April 2018

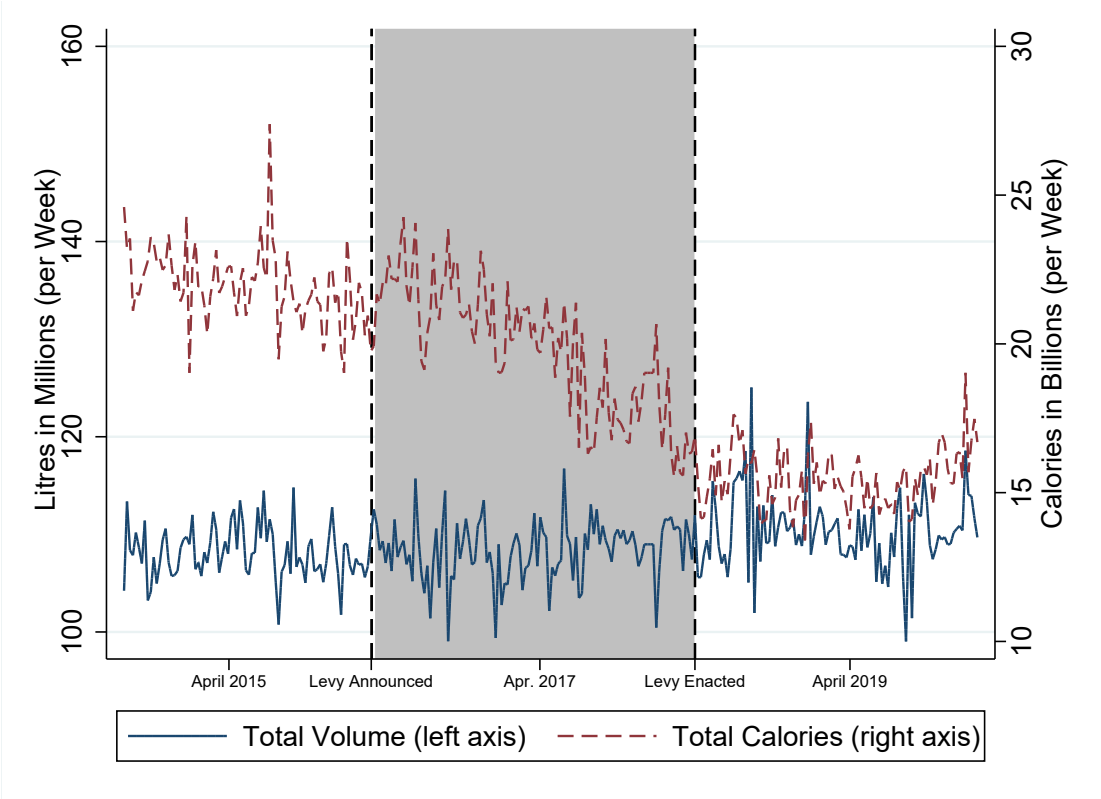
- Crucially: Beverages with $<$5g of sugar per 100ml are exempt!

Data on sugar and calorie contents allow us to analyse supply side responses which have been all but ignored by previous literature

- Product reformulation accounts for more than 80% of calorie reductions induced by UK sugar levy!

Preview: Calorie Reductions are Due to Reformulation

Figure 1: Aggregate weekly consumption for main UK soft drinks brands by volume (in millions of litres) and calories (in billions).

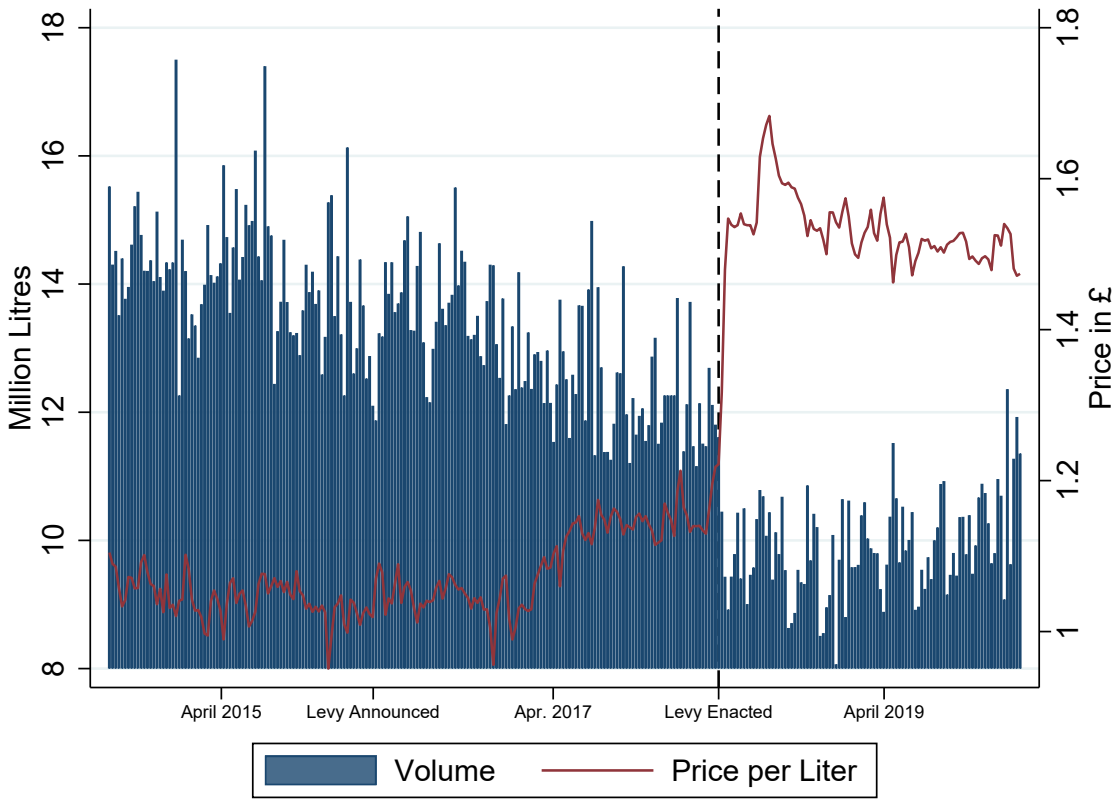


Notes: This figure shows weekly sales volume and calorie consumption for the top 100 brands in our data.

Preview of Results: Levy is Over-shifted

Moderate Demand Response and Shift into Diet Products

Figure 2: Pricing and Volume of Levied Colas



The UK Soft Drinks Industry Levy (SDIL)

Incentive and Time to Reformulate

- Time lag: Announced in March 2016, implemented in April 2018
- Tiered Nature:
  - Beverages with <5g of sugar per 100ml: zero levy
  - Beverages with 5-8g of sugar per 100ml: 18p levy
  - Beverages with >8g of sugar per 100ml: 24p levy
- Levied at manufacturer level, subject to 20% VAT
- Exceptions for milk-based drinks and fruit juices without added sugar

Substantial: Assuming 100% pass-through, price of 2l bottle increases by 57.6p!

Data on Near-Universe of Soft Drink Sales

Collected by IRi, accessed through AG Barr Plc

Electronic Point of Sale (EPOS) weekly data for **all** mainstream supermarket and convenience stores in UK from 27 July 2014 to 26 January 2020

- 45,000 stores, no coverage of continental discounters and some value retailers, and the on-trade
- Accurate read on drink-now segment (household panels capture less than 1/3 of spending)

Conduct our analysis at either brand level (focus on 100 most important brands) or market level to avoid betraying any commercially sensitive information

- Exceptions when information is in public domain
- Collected nutritional information over time

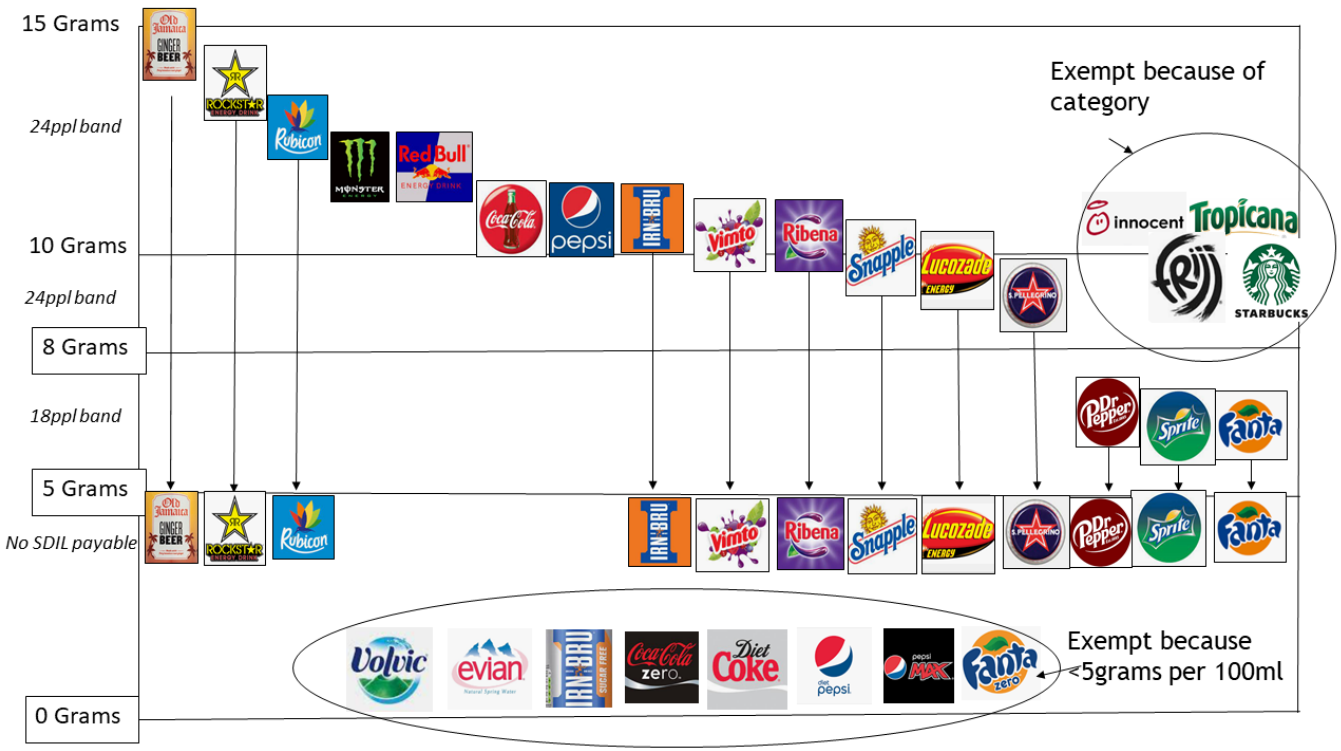
4 Groups of Brands

1. **Levied:** High sugar and subject to 24ppl levy. Colas or energy drinks.
2. **Reformulated:** Changed their recipes and as a result either partly but usually entirely avoided the levy
3. **Diet:** Artificially sweetened, sugar free containing virtually no calories. All of these brands have variants either in the reformulated or levied category.
4. **Non-Levied:** Exempt or low sugar (pre-announcement!) category, e.g. water and some lemonades.

Sum Stats Seasonal Adjustments

Reformulation: Specific Brands

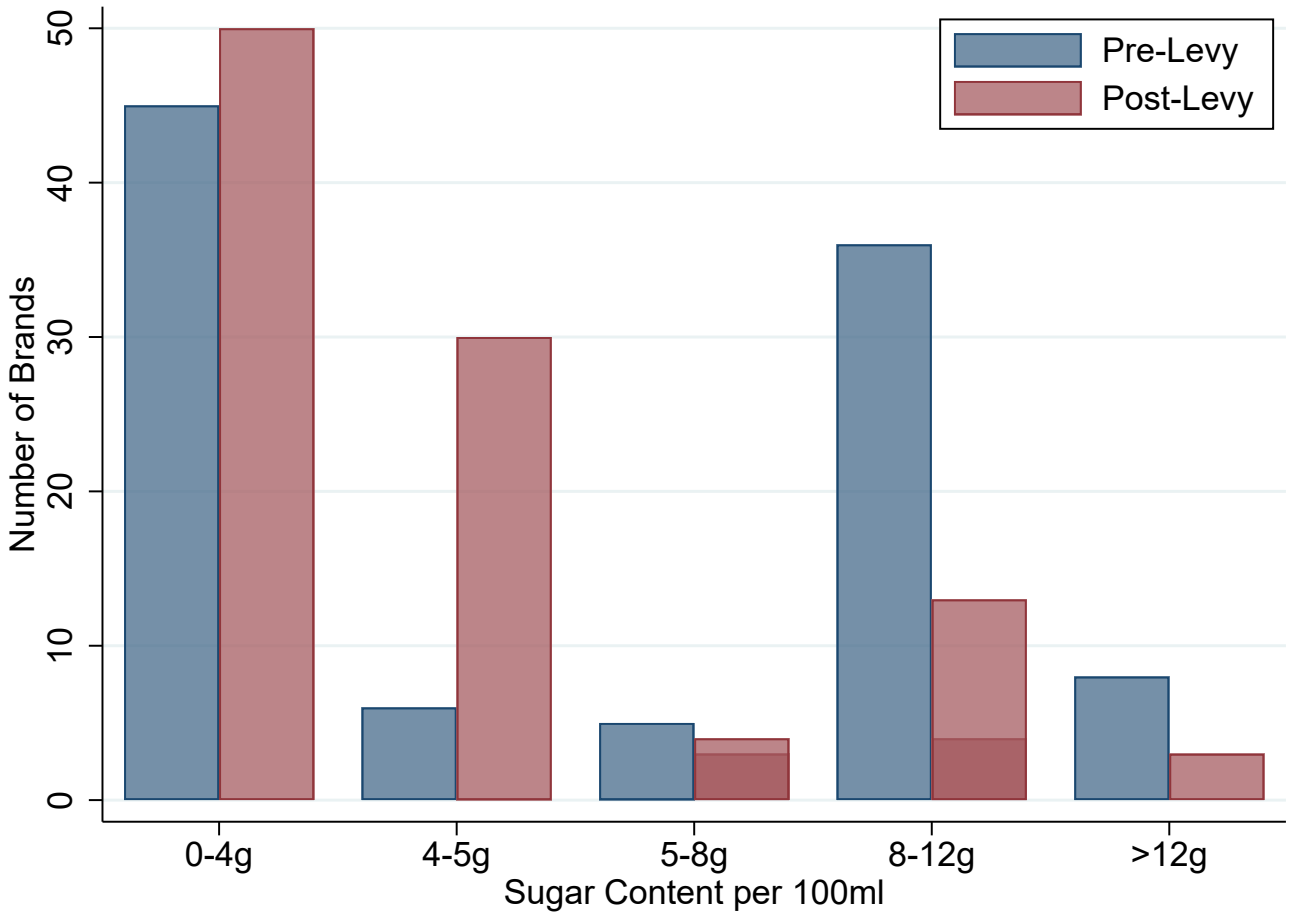
Figure 3: Brands by sugar content pre- and post-levy implementation.



Notes: Brands logos are owned by AG Barr Plc, the Coca-Cola-Company, Desnoes and Geddes Ltd, Dr Pepper Snapple Group, Group Danone, Monster Beverage Corp, Mueller Milk & Ingredients, Nestle Waters, Nichols Plc, PepsiCo, Red Bull GmbH, Starbucks Corporation, and Suntory Holdings Ltd, respectively, and were reproduced under the S30 Copyright, Designs and Patents Act 1988 (CDPA).

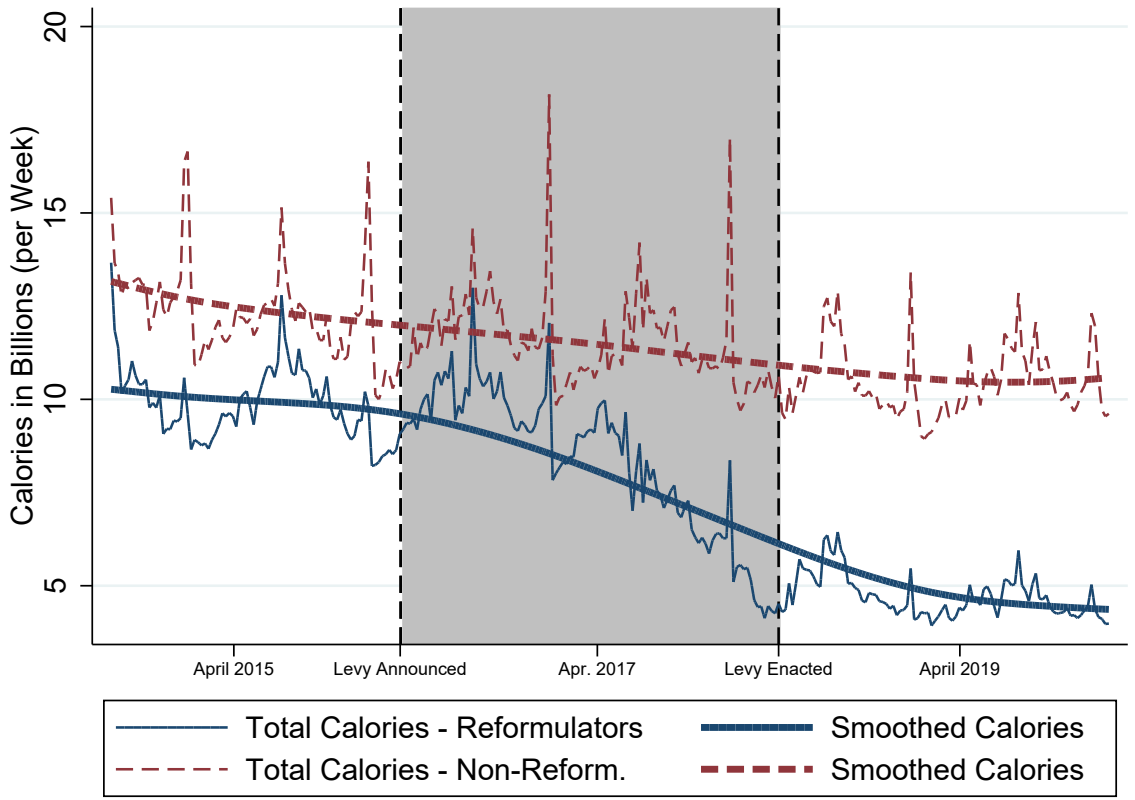
Reformulation: Graphical Evidence

Figure 4: Brands by sugar content pre- and post-levy implementation.



Reformulation: Graphical Evidence

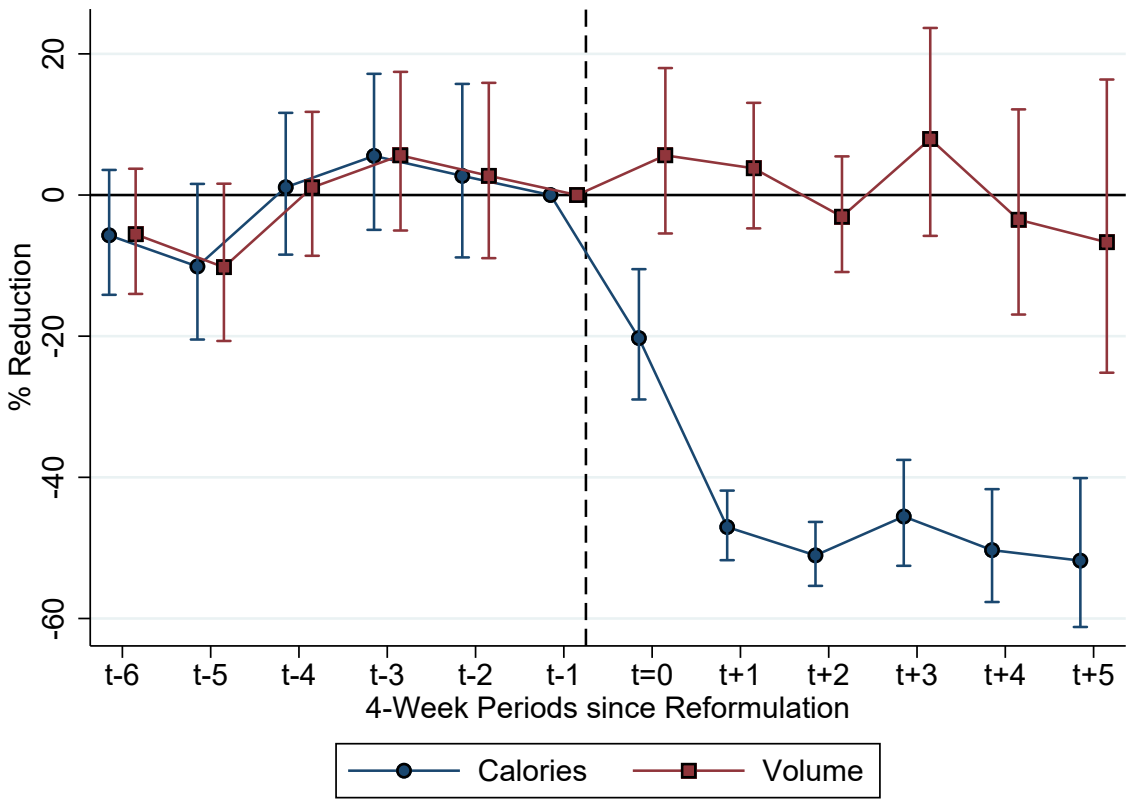
Figure 5: Total Calories Consumed: Reformulators vs Non-Reformulators



Event-Study Results (Sun & Abraham, 2021)

No effect on price or sales, but 50% drop in calories

Figure 6: Effect of reformulation on sales and calories consumed



Classic TWFE

Levied as Control

Pricing

Summary of Results - Reformulation

Don't just ignore the supply side!

Manufacturers' responses are primary driver of SDIL's success:

- Reformulation reduced calorie consumption from affected beverages by about half - before tax even went into effect!
- Neither volume nor pricing changed
- In most cases, consumers did not even notice changes
  - IrnBru is the main exception
  - Traffic light for nutritional information unchanged
- Reformulation accounted for more than 80% (sic!) of tax-induced calorie reductions

Labels

Next: Effect of Levy Implementation

Pricing, Demand-Response, Substitution

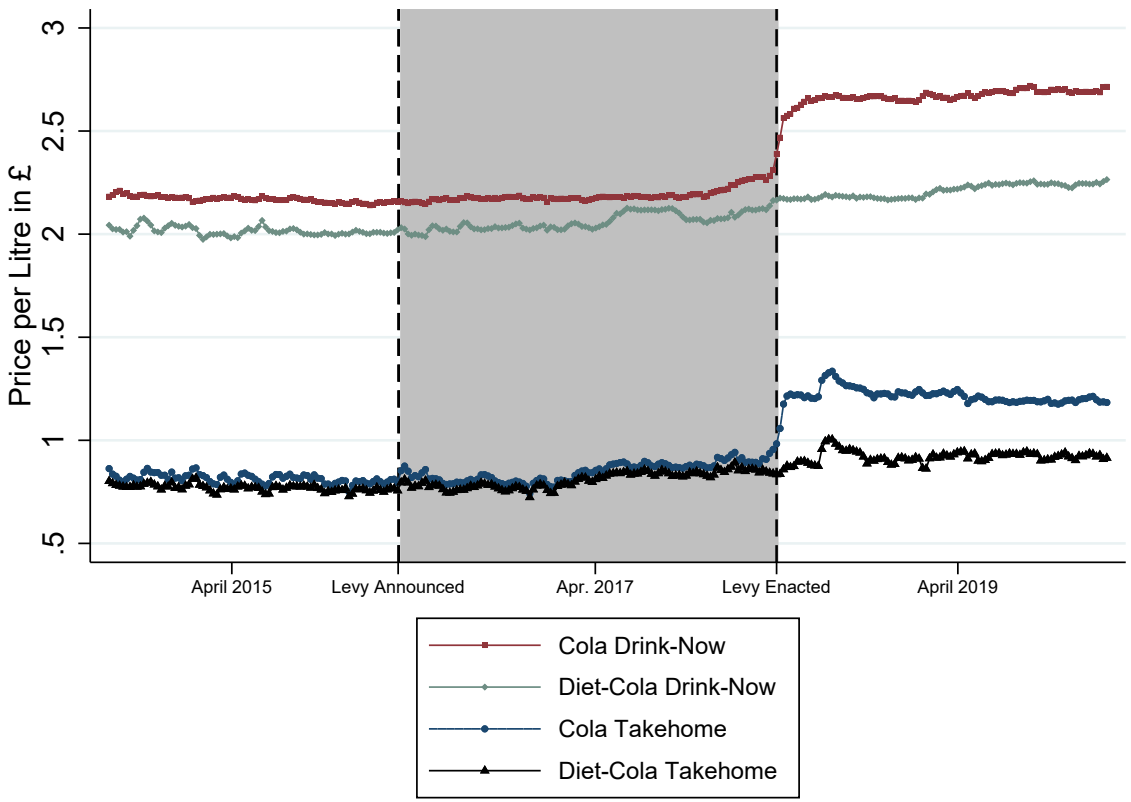
- Single policy change affecting entire market, so no natural control group for levied products.
- But: Striking break in price and volume trends allow us to quantify effects in **descriptive analysis**.
- Quantify effect sizes via interrupted time series approach (aka RDD-in-time):

$$y_{ct}^{res} = \alpha + f(Time_t) + \beta Post_t + \gamma Post_t \times f(Time_t) + \epsilon_{ct} \qquad (1)$$

Prices for Colas

28.8p levy is overshifted

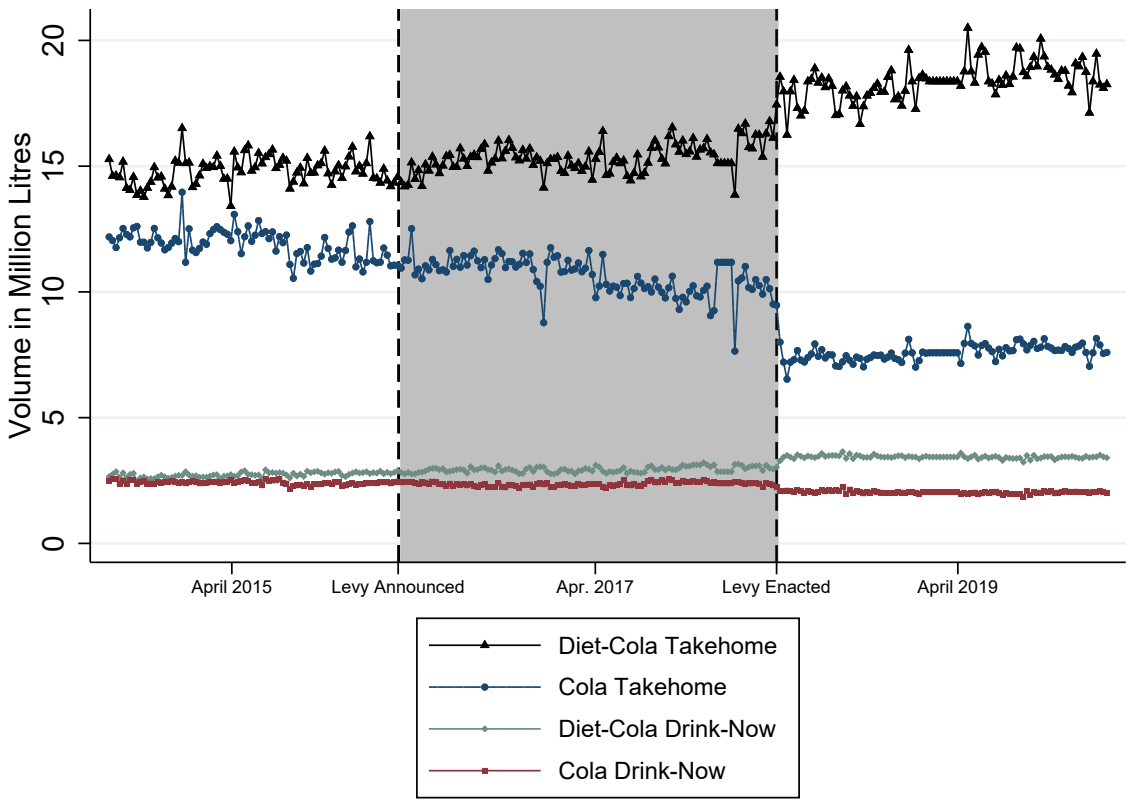
Figure 7: Pricing trends - Levied Colas and Diet Substitutes



Volume Response for Colas

About 20% Drop in Volume

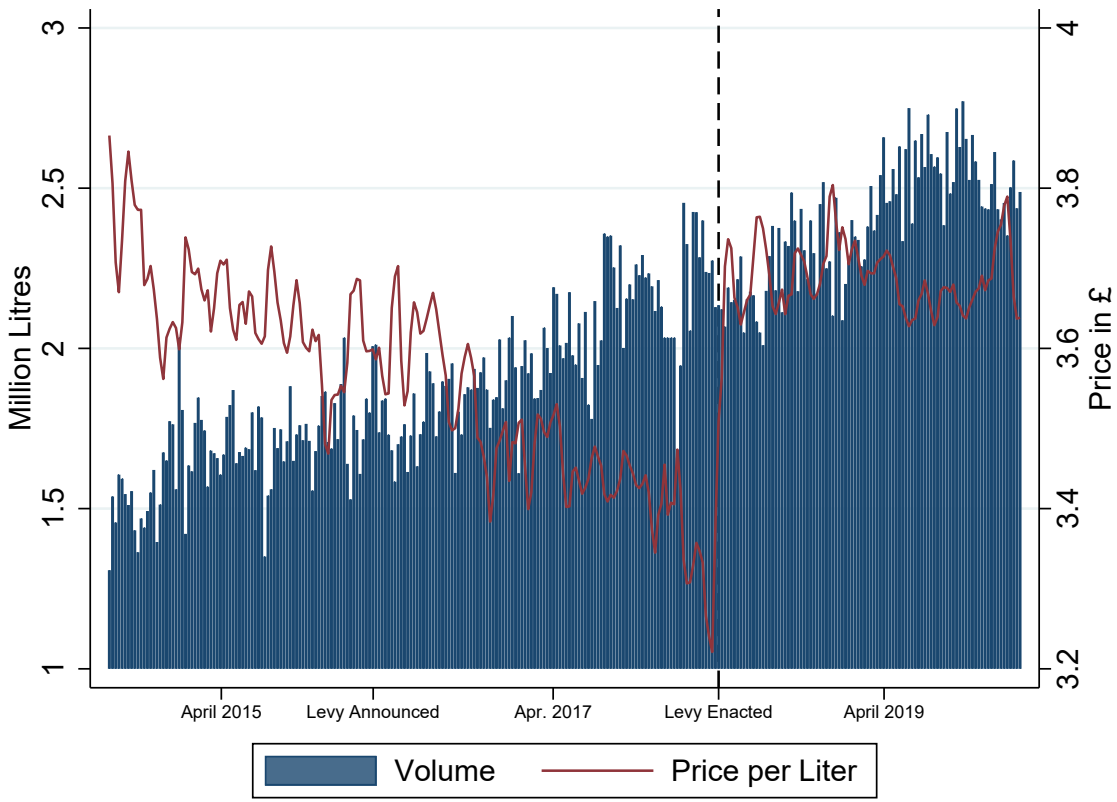
Figure 8: Pricing trends - Levied Colas and Diet Substitutes



Pricing and Volume for Energy

Take-Home and Diet-Segment are negligible!

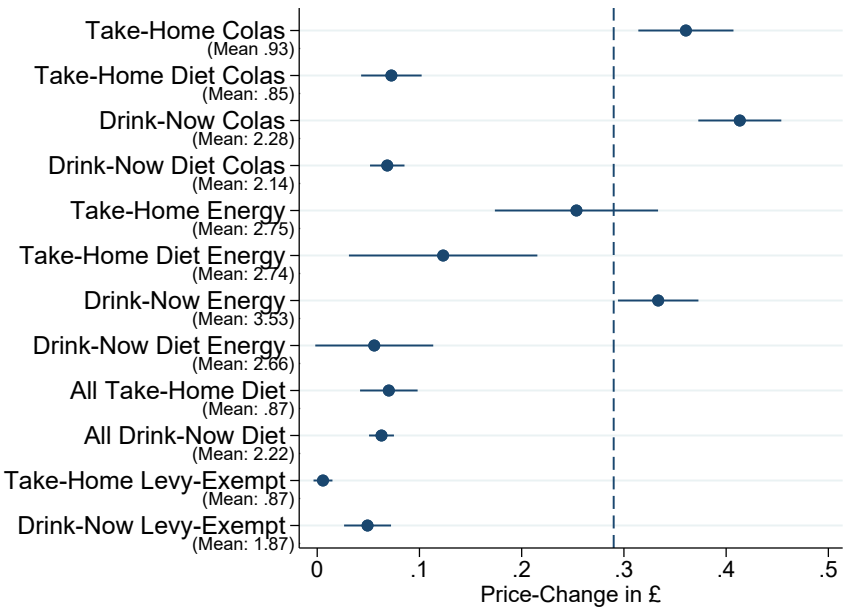
Figure 9: Price and Volume Trends - Levied Energy Drinks



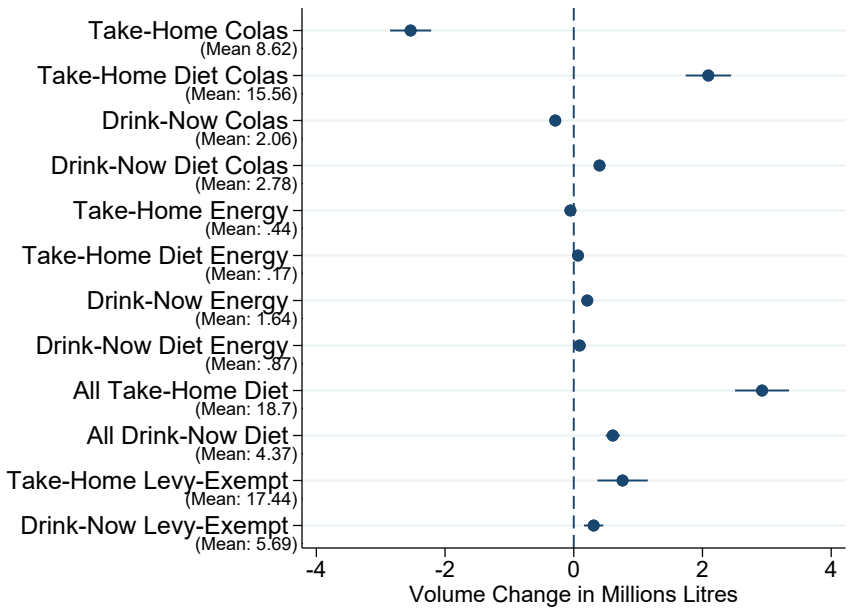
Point Estimates for Price and Volume Response

Drop in Take-Home Full-Sugar Colas is made up by Diet-Cola Sales

Figure 10: Results Interrupted Time-Series Estimation



(a) Change in Price per Litre



(b) Change in Weekly Volume

Summary of Results - Levy Implementation

Effect of the Levy on Levied Colas:

- Evidence for tax-overshifting. For take-home colas: About a 40% price increase!
- Demand response is significant. For take-home colas: About a 20% drop in consumption!
- Suggests inelastic demand.

Effect of the Levy on Diet-Colas/Products:

- Diet-Versions of levied product increased prices by 8-10p/litre.
- Increase in Diet-Cola Consumption all but offsets drop in levied cola consumption.
- Suggests substitution.

Effect of the Levy on Energy Drinks:

- Levy is slightly overshifted, but no demand response

More Detail and Robustness

Quite a few contributing factors:

- Price point targeting is an important feature "Pricing in the nines"
- Margin preservation for **both** manufacturer and retailer POR
- Container size changes Coke Bottle Size
- General inflationary pressures (present, lagged, anticipated) amid sticky prices and menu costs
- Results are not driven by differential promotion activity Promotion
- Results are not driven by changes in distribution Distribution
- Selection of Top 100 brands unlikely to miss substitution behavior
  - Most of missing coverage are own-brand labels
  - Own-brands virtually non-existent for colas and energy

Coverage Colas Coverage Energy Coverage FJ

Calorie Calculations

Reduction from 100 most important brands

- Reformulation results indicate calorie reduction of about 5.1 billion calories per week from reformulated products.
- Levy-implementation (and associated substitution) cut about another 1 billion calories per week.
- Over our entire analysis period, calorie intake dropped from about 23bn to 15bn.

Two conclusions:

1. Levy was a massive accelerator of underlying trends (on both supply and demand side) towards lower-calorie beverages
2. Reformulation was the main driver accounting for over 80% of calorie reductions

Total Calorie Reduction

Back of the Envelope Calculations

Detailed Calculation

Overall estimated calorie reduction (conservatively estimated) is 8.5bn calories per week.

- 6.3bn from off-premise sales, 0.9bn from other retail channels, 1.3bn from Foodservice and Licensed.
- This amounts to 6,600 calories per UK resident per year!

Were these reductions offset by increased consumption of high-caloric solid food? Unlikely.

- Household panel research finds no evidence for substitution from soft drinks to other sugary foods (Finkelstein et al, 2013).
- Best substitute for a sugary soft drink is a less sugary soft drink (especially if taste is similar).

Conclusion: The Levy Worked

But for reasons you may not have expected

UK SDIL led to 6.1 billion fewer calories being consumed every week (mainstream off-trade for Top 100 brands only)

- Catalyst of pre-existing trend towards low/zero sugar
- Massive, 26.5% reduction. By way of comparison, Mexico's sugar tax led to a reduction of just 2.7% (Aguilar et al, 2021)

More than 80% of reduction was due to reformulation of SSBs:

- Big implications for academics and policy: Supply-side responses are understudied yet hugely important!
- Tiered, pre-announced tax that can be avoided with levels below clearly and technically feasible target is highly effective

Comments Welcome

Thank you very much!

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UK Media as of 2014

Figure 11: Daily Mail Cover Stories

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Descriptive Statistics

Table 1: Summary statistics—top 100 brands.

	Jul 2014-Feb 2016	Mar 2016-Mar 2018	Apr 2018-Jan 2020
Panel A: All Brands			
£ per Litre	1.00	1.03	1.13
Volume in Mio Litres	106.18	108.16	112.40
Calories in Billions	22.21	19.91	15.20
Panel B: Levied Brands			
£ per Litre	1.31	1.41	1.97
Volume in Mio Litres	16.04	14.88	12.08
Calories in Billions	6.89	6.41	5.25
Panel C: Reformulated Brands			
£ per Litre	1.40	1.39	1.44
Volume in Mio Litres	21.88	21.34	20.53
Calories in Billions	9.88	8.34	4.72
Panel D: Diet Brands			
£ per Litre	1.04	1.10	1.23
Volume in Mio Litres	20.65	22.96	27.89
Calories in Billions	0.13	0.17	0.22
Panel E: Non-Levied Brands			
£ per Litre	0.69	0.72	0.75
Volume in Mio Litres	47.62	48.97	51.90
Calories in Billions	5.31	4.99	5.01
Observations	84	109	95

Notes: All values are weighted by volume.

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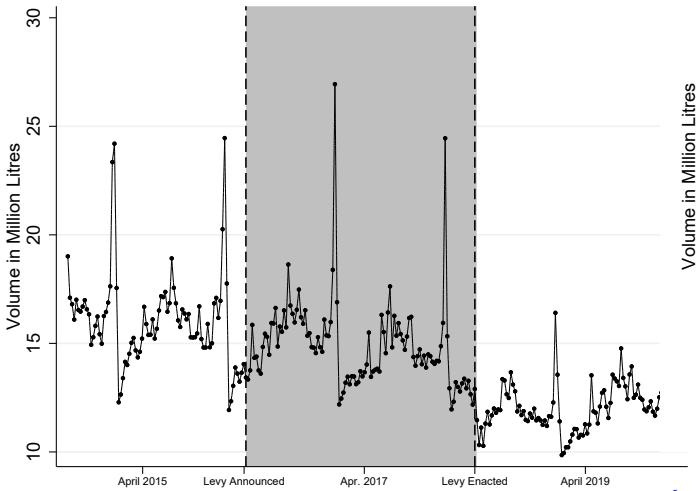
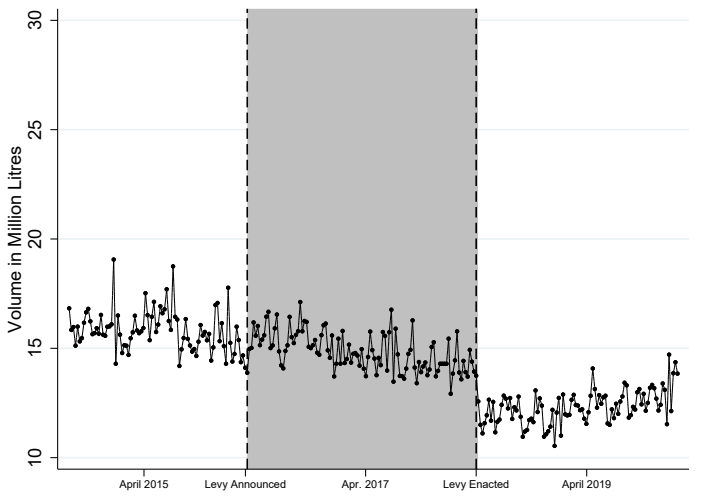
Seasonal Adjustment - Example: Levied Category

Figure 12: Seasonal adjustment–levied brand aggregates.



(a) Volume–raw data



(b) Volume–seasonally adj. data

Notes: We seasonally adjust by regressing the outcome of interest on an indicator for whether a week contains the Christmas holiday, as well as first and second-order leads and lags; year-specific Christmas dummies for 2014, 2015, and 2016; indicators for weekly mean and maximum temperature; a continuous control for rainfall as well as a set of week-of-year fixed-effects. The residuals from this regression are shifted up by the mean of the raw variable.

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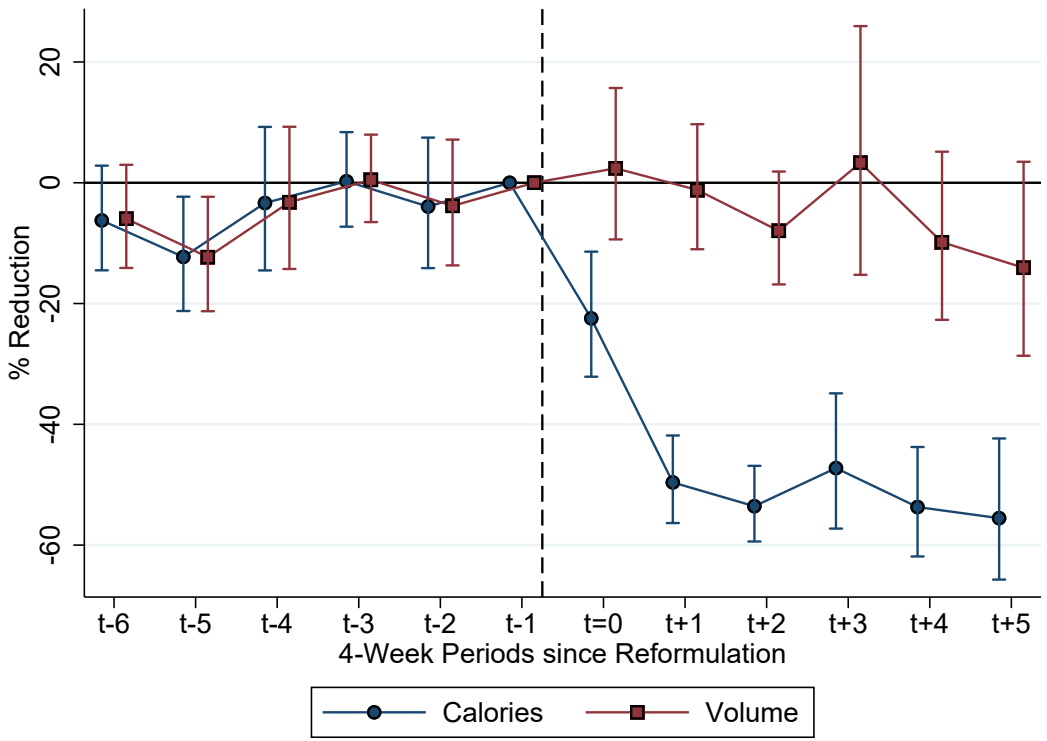
Alternative Event-Study Specification

Classic Two-way fixed effects

Figure 13: Classic Two-Way Fixed Effects Event-Study Estimation



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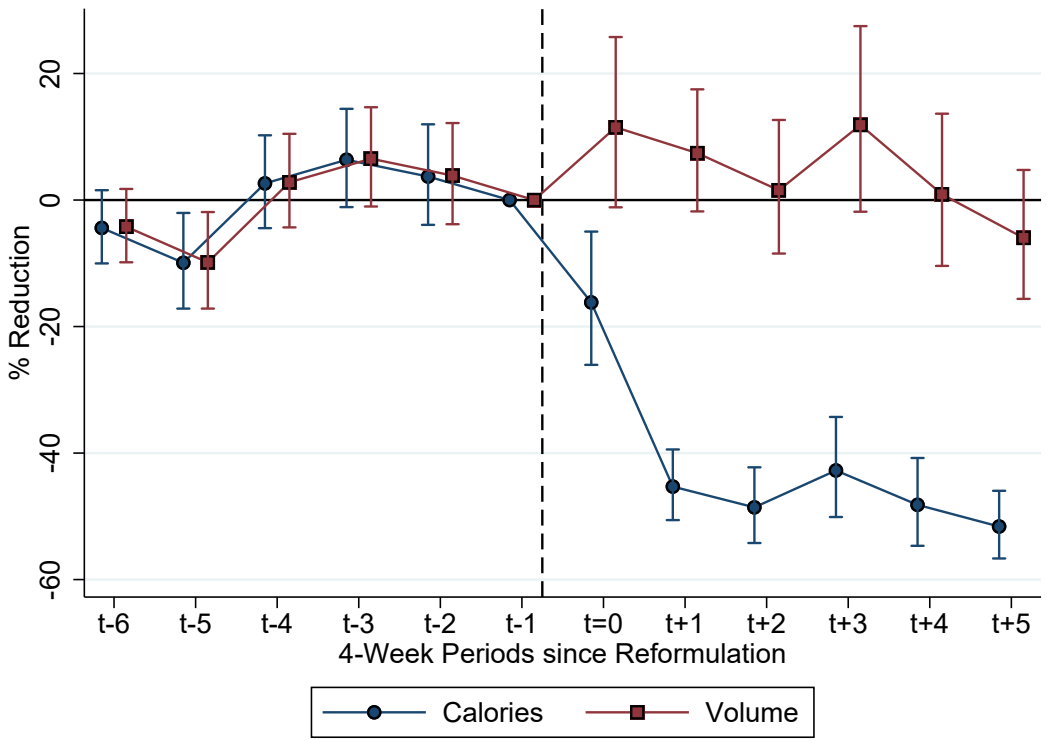
Alternative Event-Study Specification

Levied brands as controls

Figure 14: Sun and Abraham (2020) Estimator



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Nutritional Labels Before vs After

Back to Main Results

Event-Study - Raw Coefficients

Table 2: Event-Study Results

	(1) (Log) Calories	(2) (Log) Volume	(3) Cal per 100m	(4) £-Price per Litre
$t-6$	−0.0588	−0.058	0.050	−0.004
	(0.046)	(0.046)	(0.068)	(0.013)
$t-5$	−0.107*	−0.108*	0.052	0.039**
	(0.060)	(0.061)	(0.117)	(0.014)
$t-4$	0.011	0.011	0.029	−0.021
	(0.049)	(0.050)	(0.090)	(0.016)
$t-3$	0.054	0.055	−0.018	−0.009
	(0.051)	(0.052)	(0.083)	(0.016)
$t-2$	0.027	0.027	−0.001	−0.004
	(0.059)	(0.059)	(0.079)	(0.014)
$t=0$	−0.227***	0.055	−11.157***	0.005
	(0.057)	(0.054)	(0.888)	(0.012)
$t+1$	−0.636***	0.037	−22.593***	−0.041***
	(0.046)	(0.042)	(1.489)	(0.011)
$t+2$	−0.714***	−0.031	−22.860***	−0.007
	(0.045)	(0.041)	(1.476)	(0.011)
$t+3$	−0.608***	−0.076	−22.736***	0.030
	(0.068)	(0.067)	(1.500)	(0.019)
$t+4$	−0.699***	−0.036	−22.785***	−0.002
	(0.079)	(0.074)	(1.949)	(0.015)
$\geq t+5$	−0.729***	−0.069	−23.483***	−0.009
	(0.107)	(0.109)	(.879)	(0.012)

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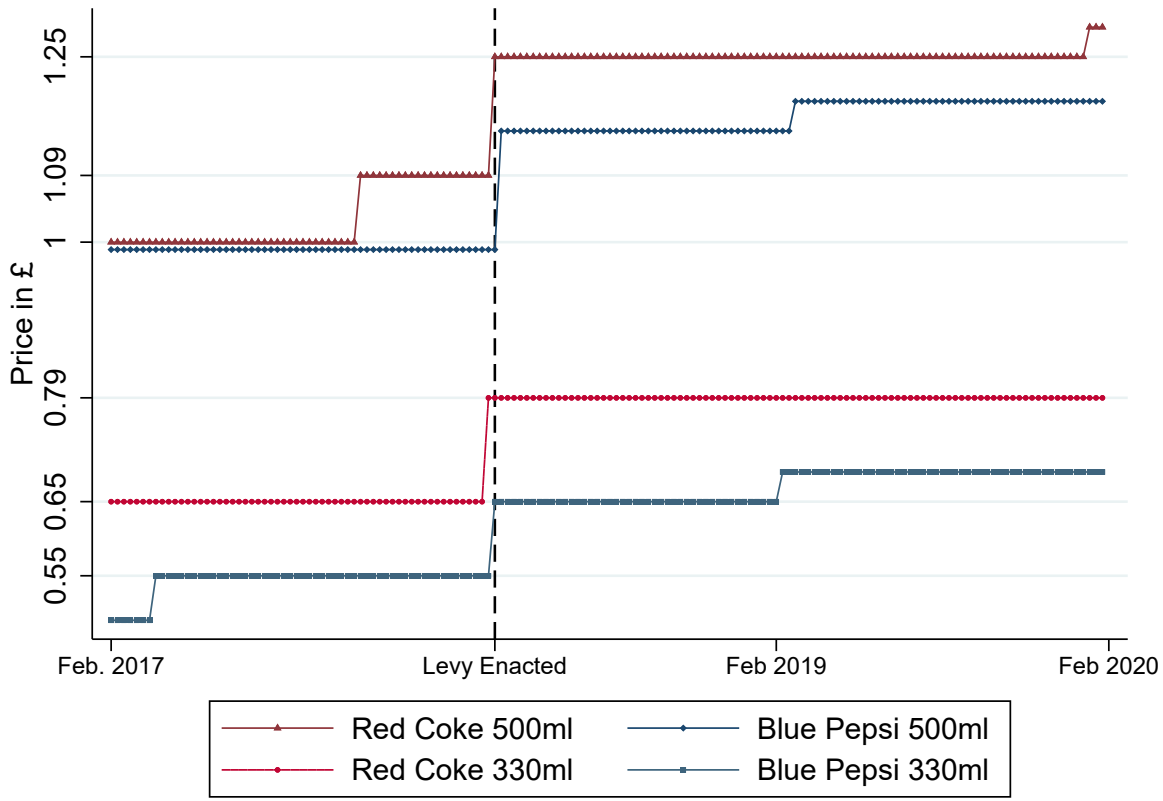
Price Marked Packs (PMPs)

What are PMPs?

Figure 15: Pricing of price-marked packs (Colas)



Back to Results

What are PMPs?

Figure 16: PMP Example

Back to PMP Chart

Coke Bottle Take-Home Bottle Size over time

Figure 17: From 2l to 1.75l to 1.5l

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Retailers' Margin Preservation

Key Performance Indicator: Profit on Return

$$POR = \frac{(P - VAT) - CostofGood}{(P - VAT)} \tag{2}$$

Assume retail price is £1, VAT rate is 20%, and cost is 58p:

$$POR = (0.833 - 0.58)/0.833 = 30\% \tag{3}$$

Now, assume manufacturer passes on 24p price increase. Also assume retailer, in turn, fully passes this on into retail price:

$$POR = (1.033 - 0.82)/1.033 = 20.6\% \tag{4}$$

Retailer would need to set P =£1.41 (i.e. **overshift!**) to preserve POR of 30%

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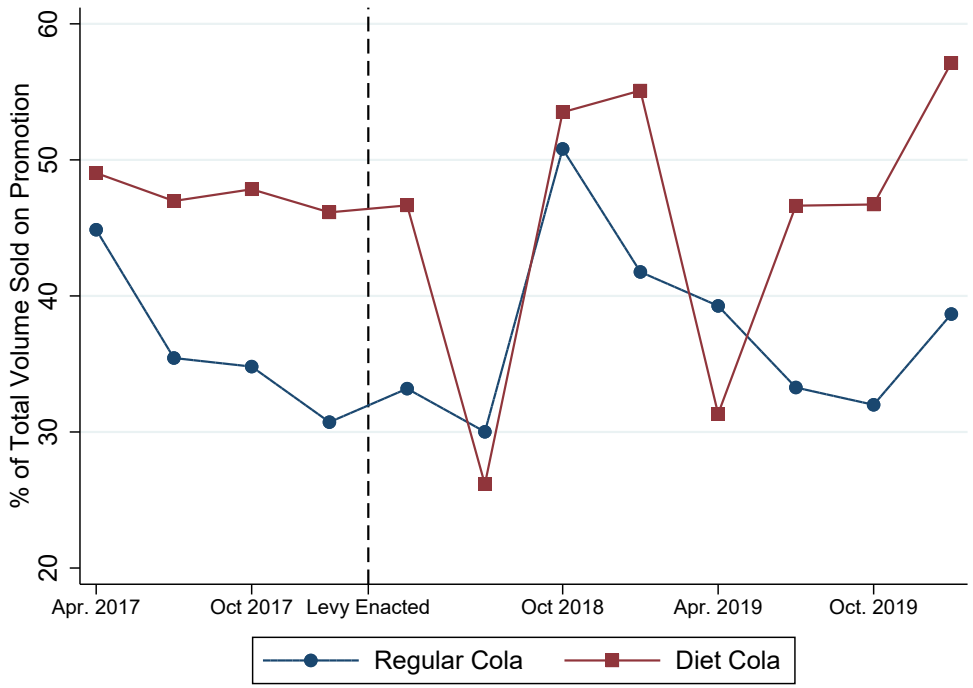
Role of Promotions

Figure 18: Promotion sales as percentage of total volume.



Notes: This figure shows the percentage of total sales volumes that was sold on promotion. Data on promotions are available at the fiscal quarterly level.

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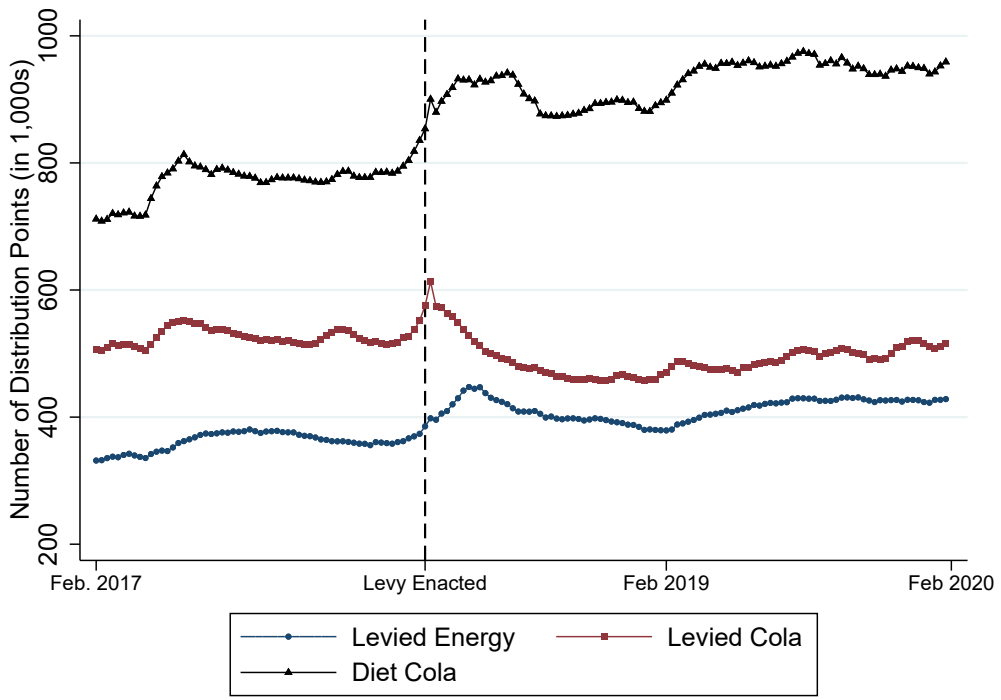
Role of Distribution

Figure 19: Number of scanning distribution points by beverage category.



Notes: This figure shows the number of distribution points—a proxy for how widely products are available—at a weekly level from February 2017 until January 2020.

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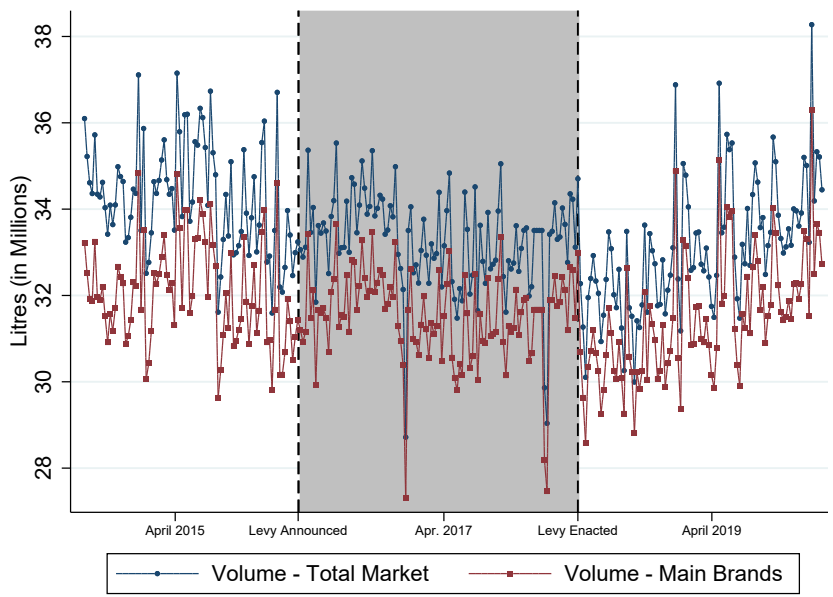
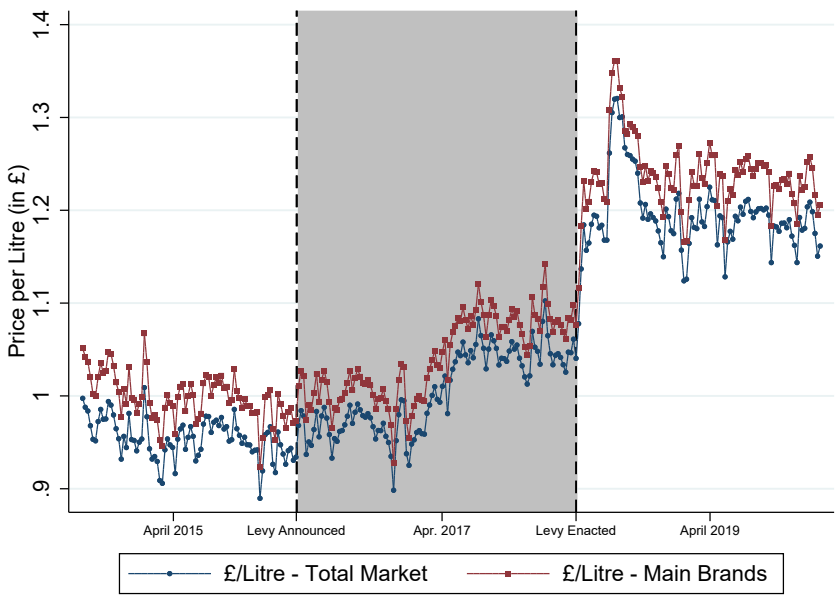
Market Coverage - Colas

Figure 20: Comparison of total market and top brands—colas.



(a) Volume



(b) Price

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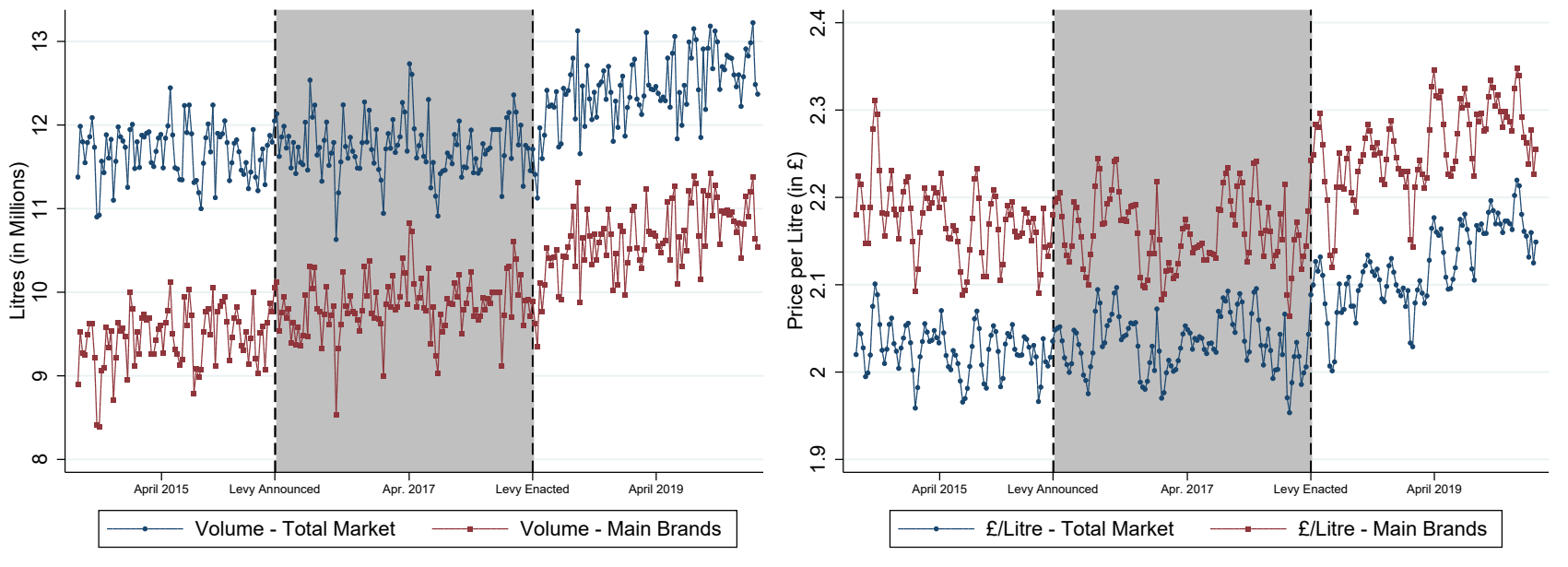
Market Coverage - Energy

Figure 21: Comparison of total market and top brands—sports & energy.



(a) Volume

(b) Price

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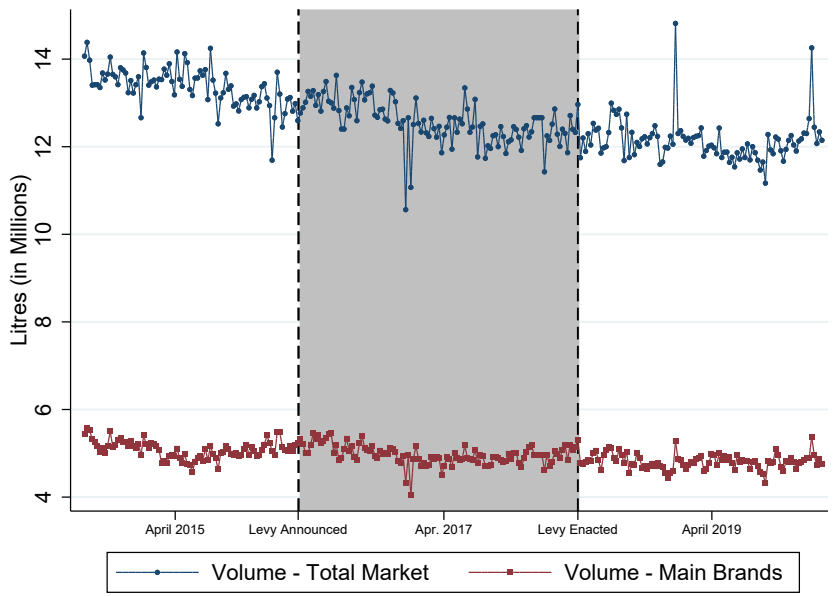
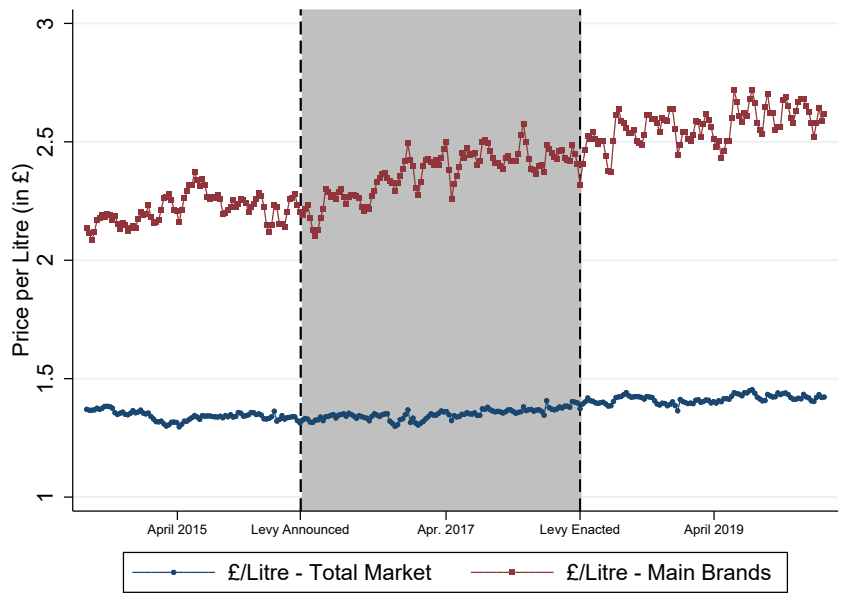
Fruit Juices - Role of Own brands

Figure 22: Top brands vs full-market comparison—fruit juice.



(a) Volume



(b) Price

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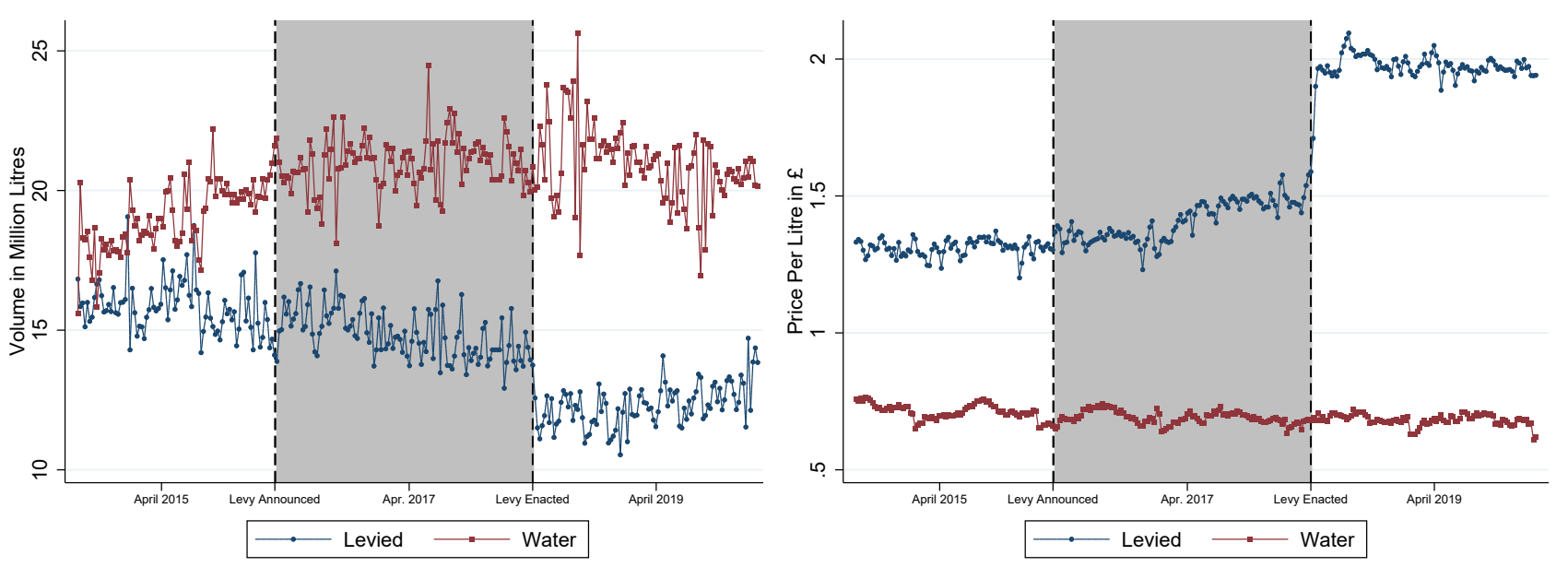
Water as Control Group

Figure 23: Water as a control group.



(a) Volume

(b) Price

Notes: This figure shows trends in volume sales as well as price per litre for levied brands (blue circles) and levy-exempt water (red squares).

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Total Calorie Reduction

Back of the Envelope Calculations

Assume that own-label brands all reformulated if they had to since they compete on price.

- Know their shares in all segments and whether they would fall under levy.
- Amounts to 165m calorie reduction per week
- Takes us to 93.1% of EPOS coverage

Remaining 6.9% are very small brands, many of which were levy-exempt

- Conservative assumption: No reformulation, no reduction

Back of the Envelope Calculations

Continental discounters and value stores

- According to household panel data: account for 1.5bn litres
- Assuming that discounters sell same product mix as main street, this implies another 0.9bn reduction

Foodservice and Licensed (e.g. on-trade) sells about 1.8bn litres p.a. (Britvic, 2019) which held stable over time.

- Any price increase much smaller in real terms, so assume no reduction in consumption for levied products
- For reformulating segments (e.g. OFC, fruit drinks) we assume 50% calorie reduction due to reformulation.
- Conservative estimate: Reduction of 1.2bn calories/week.

Back to Main Slide Deck