The distributional effects of a soda tax

Pierre Dubois, Rachel Griffith and Martin O'Connell

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Motivation

- Governments across the world are concerned about high and rising rates of obesity; sugar sweetened beverages are a prime contributing factor
- Public health community has advocated the use of soda taxes
  - In 2012 France became first country to introduce a tax targeted specifically at soda, followed in 2013 by Mexico
  - This year:
    - Philadelphia passed legislation for a tax of 1.5 cents per ounce on both sodas with added sugar and artificial sweeteners
    - UK Government announced plans for a tax on soda with added sugar
- Controversy surrounding whether such measures will successfully lower sugar consumption among those most in need of change and to what extent the measures will be regressive.

Aim of paper

- We provide empirical evidence on the impact on consumer demand for soda of implementing a soda tax
  - Estimate demand in UK soda market exploiting longitudinal data on purchases of a panel of individual consumers
  - For each consumer we estimate their price, soda and sugar preference parameters, imposing no distributional assumption on the joint distribution
  - Allows us to capture distributional impact of introducing tax
  - And to relate preferences and predictions to other information about consumers (e.g. total sugar in diet and measure of income)
- We compare a Philadelphia style tax on all soda (soda tax) with a revenue equivalent UK style tax which targets only soda with added sugar (sugary soda tax)

Use novel data set

- Use data on purchases made by a panel of consumers of food and drink bought "on-the-go"
- We observe 5199 consumers in total
  - 1103 never purchase drinks; 1773 only purchase non soda drinks; 2363 are soda purchasers
- We observe each consumer making purchases on at least 25 separate days (81 on average)
- Food/drink "on-the-go" is an important segment of junk food markets, yet little is known about on-the-go demand
- Alleviates concerns about stocking-up and intra-household allocation contaminating demand estimates

Soda demand

- Consumers typically purchase one product on a purchase occasion
- They select from set of popular, differentiated products; e.g.
  - Coca Cola 330ml can
  - Pepsi Diet 500ml bottle

  and outside option of a non-soda drink
- We model demand using discrete choice framework
  - Utility from a given product is a function of consumer's valuation of product attributes
  - Plus an additive (logit) shock
  - Consumer assumed to select the option that provides the highest utility

Utility specification

Consumer i on purchase occasion t chooses between soda products, $j \in \{1, ..., J\} = \Omega$, and outside option, $j = 0$

Inside option utility ($j > 0$):

$$U_{ijt} = \alpha_i + \beta_i p_{jrt} + \gamma_i s_j + g_i(\mathbf{x}_{jt}) + \epsilon_{ijt}$$

p_{jrt} price of product j at time t in store r
s_j indicator of sugary vs. diet
$\mathbf{x}_{jt}$ additional product attributes (pack size effect; time varying brand effects)
ϵ_{ijt} type I extreme value deviate

Outside option utility ($j = 0$):

$$U_{i0t} = \zeta_{drt} + \epsilon_{i0t}$$

ζ_{drt} demographic group d-time t-store r effect

Preference heterogeneity

- Soda (α_i), price (β_i) and sugar (γ_i) preferences are consumer specific
- We treat $\boldsymbol{\alpha} = (\alpha_1, ...\alpha_N)'$, $\boldsymbol{\beta} = (\beta_1, ...\beta_N)'$ and $\boldsymbol{\gamma} = (\gamma_1, ...\gamma_N)'$ as parameters
  - Using large T dimension of data to recover estimates of $(\boldsymbol{\alpha}, \boldsymbol{\beta}, \boldsymbol{\gamma})$
  - And large N dimension to construct nonparametric estimate of $f(\alpha_i, \beta_i, \gamma_i)$
- We also allow for the possibility of infinite regions of the parameter space
  - For instance, consumers that never purchase sugary (non-diet) products have $\gamma_i = -\infty$

Our approach vs. random coefficient logit

- It's well understood that incorporating preference heterogeneity is important for capturing realistic substitution patterns
- Standard approach is to model heterogeneity using a parametric distribution – e.g. consumer specific coefficients are random draws from independent normals
- Strength of our alternative approach is
  - We do not need to impose functional form assumptions on preference distribution
  - We recover consumer specific parameters and therefore can relate them to other information about consumers

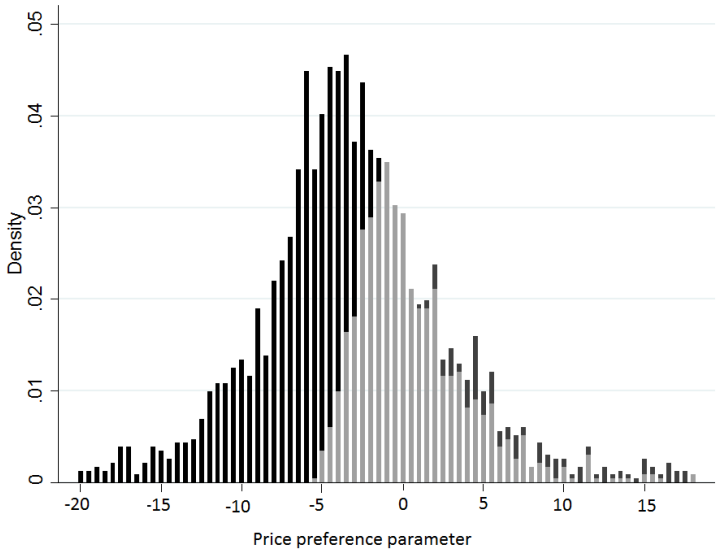
Soda products

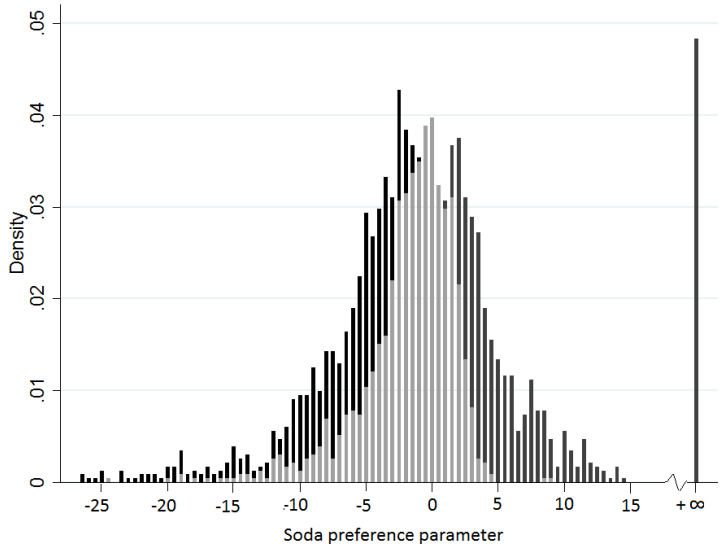
Product			Market share	Price (£)	g sugar per 100ml
Brand	Regular/diet	Pack size			
Coca Cola			45.5%		
	Regular	330ml can	6.2%	0.63	10.6
	Regular	500ml bottle	12.6%	1.08	10.6
	Diet	330ml can	6.8%	0.63	0.0
	Diet	500ml bottle	19.9%	1.07	0.0
Fanta			7.3%		
	Regular	330ml can	1.0%	0.59	6.9
	Regular	500ml bottle	5.5%	1.07	6.9
	Diet	500ml bottle	0.8%	1.06	0.6
Cherry Coke			5.7%		
	Regular	330ml can	0.8%	0.65	11.2
	Regular	500ml bottle	3.3%	1.07	11.2
	Diet	500ml bottle	1.6%	1.06	0.0
Ribena			5.2%		
	Regular	288ml carton	0.9%	0.67	10.5
	Regular	500ml bottle	3.1%	1.12	10.5
	Diet	500ml bottle	1.2%	1.12	0.5
Pepsi			18.7%		
	Regular	330ml can	1.4%	0.60	11.0
	Regular	500ml bottle	3.6%	0.94	11.0
	Diet	330ml can	1.9%	0.61	0.0
	Diet	500ml bottle	11.7%	0.93	0.0
Lucozade			9.1%		
	Regular	380ml bottle	4.3%	0.94	13.8
	Regular	500ml bottle	4.9%	1.13	13.8
Oasis			8.5%		
	Regular	500ml bottle	7.8%	1.07	4.1
	Diet	500ml bottle	0.7%	1.05	0.5

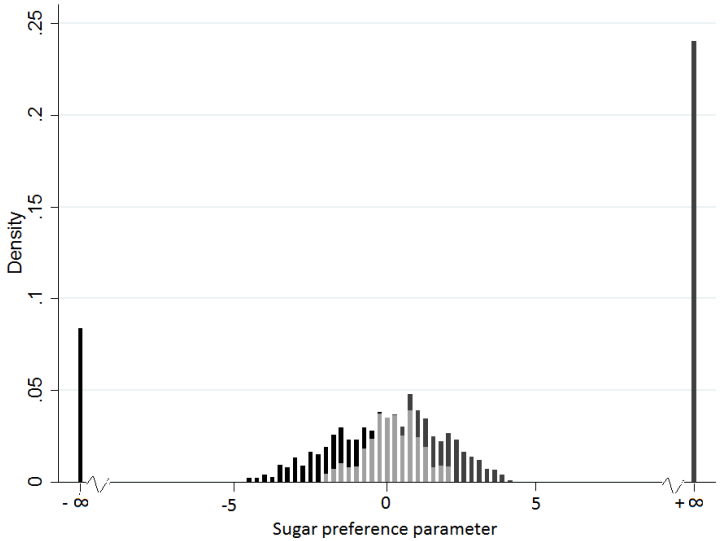
Model estimates

Moments of distribution of consumer specific preferences			
Variable		Estimate	Standard error
Price	Mean	-3.0985	0.0925
	Standard deviation	5.9174	0.0948
	Skewness	0.3353	0.0966
	Kurtosis	4.2871	0.2833
Soda	Mean	-1.5635	0.0894
	Standard deviation	5.8820	0.1046
	Skewness	-0.6427	0.1072
	Kurtosis	4.5701	0.4237
Sugar	Mean	0.0532	0.0182
	Standard deviation	1.7495	0.0200
	Skewness	-0.2008	0.0404
	Kurtosis	2.4635	0.0692
Price-Soda	Covariance	-31.7067	1.1204
Price-Sugar	Covariance	0.6170	0.1371
Soda-Sugar	Covariance	-2.4481	0.1458

Marginal preference distributions

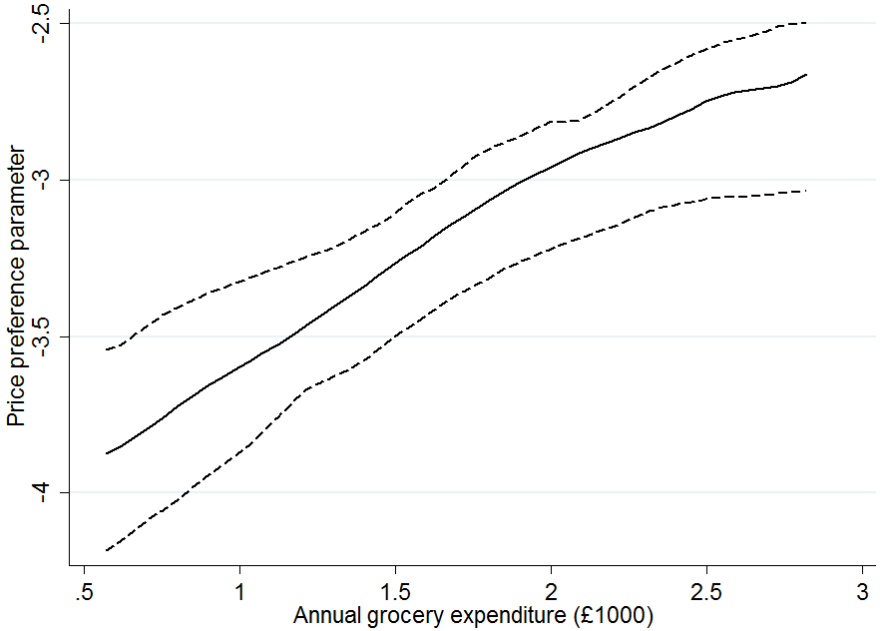


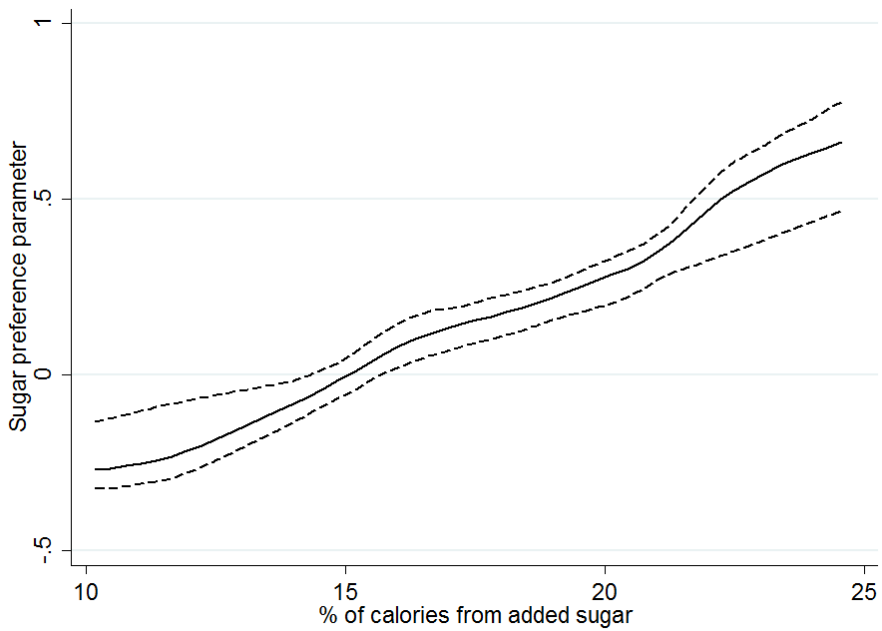




Negative
Indifferent
(not statistically different from zero)
Positive

How preferences relate to broader measures of behaviour





- Consumers with low annual grocery expenditure more price sensitive
- Consumers with high share of total sugar in diet have stronger sugar preference

Price effects

	own demand	Effect of 1% price increase on: cross demand for: sugary products	diet products	total demand
Coca Cola 330	-3.954	0.178	0.067	-0.049
Coca Cola 500	-1.231	0.154	0.065	-0.142
Coca Cola Diet 330	-3.668	0.070	0.294	-0.033
Coca Cola Diet 500	-1.858	0.068	0.463	-0.161
Fanta 330	-4.425	0.047	0.015	-0.011
Fanta 500	-1.276	0.018	0.011	-0.025
Fanta Diet 500	-2.157	0.012	0.068	-0.029
Cherry Coke 330	-4.644	0.028	0.008	-0.006
Cherry Coke 500	-1.339	0.018	0.011	-0.023
Cherry Coke Diet 500	-2.159	0.011	0.061	-0.024
Ribena 288	-4.214	0.043	0.016	-0.006
Ribena 500	-0.814	0.003	0.007	-0.013
Ribena Diet 500	-1.710	0.006	0.035	-0.016
...				

Counterfactual soda tax

- We simulate a Philadelphia and UK style soda tax
  - A 25p tax per litre on all soda (Philadelphia style)
  - A 48p tax per litre on only sugary soda (UK style)
- Rates chosen to be revenue equivalent
- We explore the demand effects of each tax

Aggregate effects

	% change in demand for:		
	sugary soda	diet soda	all soda
Soda tax	-9.1	-10.4	-9.6
	[-9.5, -8.3]	[-10.8, -9.5]	[-10.1, -8.9]
Sugary soda tax	-16.2	4.7	-6.9
	[-16.8, -14.2]	[4.1, 5.3]	[-7.2, -6.1]

Effects of tax by overall dietary sugar

		Quartile of added sugar distribution			
		1	2	3	4
		Mean	Difference in mean with quartile 1		
Volume (l)	Pre tax	8.50	-0.85	-0.70	-0.68
		[8.47, 8.65]	[-0.95, -0.72]	[-0.76, -0.50]	[-0.78, -0.51]
Δ volume (l)	Soda tax	-0.94	0.08	0.04	0.12
		[-1.00, -0.86]	[0.02, 0.15]	[-0.04, 0.10]	[0.04, 0.18]
	Sugary soda tax	-0.66	0.02	-0.02	0.03
		[-0.71, -0.56]	[-0.04, 0.12]	[-0.11, 0.07]	[-0.10, 0.11]
Sugar (100g)	Pre tax	4.19	0.13	0.56	1.06
		[4.17, 4.31]	[0.04, 0.25]	[0.45, 0.72]	[0.95, 1.18]
Δ sugar (100g)	Soda tax	-0.47	-0.01	-0.01	0.00
		[-0.51, -0.43]	[-0.04, 0.05]	[-0.06, 0.03]	[-0.06, 0.05]
	Sugary soda tax	-0.94	0.06	0.01	0.13
		[-1.01, -0.81]	[-0.04, 0.17]	[-0.13, 0.10]	[-0.01, 0.23]

Effects of tax by total spending

		Quartile of grocery expenditure distribution			
		1	2	3	4
		Mean	Difference in mean with quartile 1		
Volume (l)	Pre tax	8.13	0.26	-0.28	-0.53
		[8.08, 8.35]	[0.07, 0.39]	[-0.41, -0.09]	[-0.65, -0.38]
Δ volume (l)	Soda tax	-1.03	0.15	0.18	0.25
		[-1.11, -0.95]	[0.09, 0.23]	[0.11, 0.27]	[0.17, 0.33]
	Sugary soda tax	-0.85	0.18	0.20	0.34
		[-0.95, -0.72]	[0.09, 0.27]	[0.14, 0.33]	[0.24, 0.48]
Sugar (100g)	Pre tax	5.04	-0.11	-0.39	-0.86
		[5.00, 5.18]	[-0.19, 0.01]	[-0.50, -0.28]	[-0.96, -0.75]
Δ sugar (100g)	Soda tax	-0.62	0.14	0.15	0.23
		[-0.67, -0.54]	[0.11, 0.20]	[0.12, 0.21]	[0.18, 0.30]
	Sugary soda tax	-1.14	0.23	0.24	0.41
		[-1.26, -1.00]	[0.14, 0.36]	[0.16, 0.41]	[0.29, 0.56]

Tax burden by total spending: compensating variation

	Quartile of grocery expenditure distribution			
	1	2	3	4
	Mean	Difference in mean with quartile 1		
Soda tax	1.90	0.09	-0.05	-0.10
	[1.88, 1.95]	[0.04, 0.13]	[-0.09, 0.00]	[-0.13, -0.06]
Sugary soda tax	2.07	0.02	-0.11	-0.30
	[2.05, 2.15]	[-0.02, 0.10]	[-0.19, -0.04]	[-0.37, -0.25]

Summary

- Model demand in the soda market, estimating consumer specific preference parameters for soda, price and sugar
- Use estimates to explore demand responses to soda tax

- Tax levied only on sugary soda induces larger reduction in sugar but smaller reduction in total soda than comparable tax levied on all soda
- Little evidence either tax specifically targets consumption of individuals with high share of added sugar in diet
- Consumers with lower total spending respond more strongly than higher expenditure consumers