Institute for Fiscal Studies

MANCHESTER 1824

Recent advances in Public Economics: using demand estimates to inform policy

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Plan of the lectures

Lecture 1

- what are the effects of sin taxes?
- empirical approaches to estimate suitably flexible demand models

Lecture 2

- what are the effects of restrictions to advertising?
- empirical approaches to estimate suitably flexible demand models
- evaluating welfare with possible behavioural effects

Motivation

- Advertising of some sin good is restricted - e.g. tobacco, alcohol, unhealthy foods on children's TV
- recent legislation restricts advertising of unhealthy foods before 9pm
- ex ante we don't know what impact, depends on
  - how the demand shape changes with advertising
  - strategic response of firms: price equilibrium
- counterfactual evaluation of supply and demand can be informative
- Welfare effects will depend on whether advertising is: informative, distortionary, characteristic

Draws on this paper

Dubois, Griffith and O'Connell (2018) "The effects of banning advertising in junk food markets" Review of Economic Studies, 85:1, 396 - 436

but also relevant are

Abi-Rafeh, Rossi, Pierre Dubois, Rachel Griffith and Martin O'Connell (2023) "The effects of sin taxes and advertising restrictions in a dynamic equilibrium" CEPR DP 18527 (on my website)

Crawford, G., R. Griffith and A. Iaria (2021) "A Survey of Preference Estimation with Unobserved Choice Set Heterogeneity" Journal of Econometrics, 222:1, 4-43

Policy aims

- Policy makers are interested in encouraging people to consider nutrition when deciding what foods to buy
- one area of concern has been advertising for unhealthy snacks
- from an economic perspective advertising can be (see Bagwell, 2007)
  - Informative about prices/characteristics (Stigler, 1961; Nelson, 1995)
  - A characteristic that consumers value (Stigler and Becker, 1977)
  - Persuasive (Marshall, 1921; Robinson, 1933; Kaldor, 1950)

Persuasive view of advertising

- Advertising can lead consumers to act as non-standard decision makers, by providing environmental "cues" to consumers (Bernheim and Rangel, 2005).
- Bernheim and Rangel (2009): *"choices made in the presence of those cues are predicated on improperly processed information, and welfare evaluations should be guided by choices made under other conditions"*

Dubois, Griffith and O'Connell (2018)

Develop model of consumer demand and oligopoly supply with multi-product firms competing in price and advertising

- allow advertising to impact demand in a flexible way
- allow past advertising to impact current demand, meaning firms play a dynamic game
- estimate the model on the UK potato chips
- simulate the impact of advertising ban on equilibrium outcomes (prices, expenditures, quantities, nutrition)
  - because consider a ban don't need to solve dynamic supply side equilibrium
- consider welfare evaluation - depends on whether advertising distorts consumer's choices or enters utility as a characteristic

Advertising in consumer demand model

Model consumer choice:

- Allow cooperative or rival effects of advertising, such that increase in advertising of one brand may:
  - increase demand for another brand (cooperative)
  - decrease demand for another brand (predatory)
  - lead to expansion or contraction of market
- Allow dynamic effects of advertising on demand:
  - $\mathbf{a}_{bt}$: advertising stock for brand b, depends on current and past advertising expenditures (e)

$$\mathbf{a}_{bt} = \mathbf{f}(e_{bt}, e_{bt-1}, e_{bt-2}, ..., e_{b0})$$

Discrete choice demand model

- consumer i's payoff (decision utility) from brand b, pack size s, time (market) t:

$$\bar{v}_{ibst} = \alpha_i\left(\mathbf{a_{bt}}, p_{bst}\right) + \psi_i\left(\mathbf{a_{bt}}, x_b\right) + \gamma_{bi}(\mathbf{a_t}) + \eta_i(\mathbf{z}_{bs}, \xi_b) + \epsilon_{ibst}$$

where:
p_{bst}: price
x_b: nutrient quality
$\mathbf{a_{bt}}$: advertising states for brand b; $\mathbf{a_t} = (\mathbf{a_{1t}}, ..., \mathbf{a_{Bt}})$
z_{bs}: pack size
ξ_b: an unobserved brand characteristic
ϵ_{ibst}: individual deviation that may contain some product specific time varying unobservables

- Outside good : $\bar{v}_{i00t} = \zeta_{d0t} + \epsilon_{i00t}$

A suitably flexible demand specification

$$\begin{aligned}
\alpha_i\left(\mathbf{a_{bt}}, p_{bst}\right) &= \left(\alpha_{0i} + \alpha_{1i}\mathbf{a_{bt}}\right) p_{bst} \\
\psi_i\left(\mathbf{a_{bt}}, x_b\right) &= \left(\psi_{0i} + \psi_{1i}\mathbf{a_{bt}}\right) x_b \\
\gamma_{bi}(\mathbf{a_t}) &= \lambda_i \mathbf{a_{bt}} + \rho_i \left(\sum\nolimits_{l \neq b} \mathbf{a_{lt}}\right) \\
\eta_i(\mathbf{z}_{bs}, \xi_b) &= \eta_{1i} z_{bs} + \eta_{2i} z_{bs}^2 + \eta_i \xi_b
\end{aligned}$$

where $\pi_i^u = (\alpha_{0i}, \lambda_i, \rho_i, \eta_i)$ such that $\pi_i^u = \pi_0^u + \pi_1^u d_i + \upsilon_i d_i$ with $\upsilon_i \sim N(0, \Sigma_\pi)$ and $\pi_i^o = (\alpha_{1i}, \psi_{1i}, \eta_{1i}, \eta_{2i})$ with $\pi_i^o = \pi_0^o + \pi_1^o d_i$

- Coefficients differ by demographics (d_i) and purchase occasion
- All advertising coefficients allow potential shift with consumer's observed and unobserved exposure to advertising

A suitably flexible demand specification

- interaction of the advertising state variable with price and the nutrient characteristic, and the possibility that competitor advertising directly enters the payoff function are important in allowing for advertising to flexibly impact demands
- by including competitor advertising in the payoff function we allow for the possibility that, regardless of the sign of own demand advertising effects, advertising may be predatory or cooperative and it may lead to market expansion or contraction

Market demand

- Consumer faces choice set Ω_κ, chooses (b, s) if:

$$\bar{v}_{ibst} \geq \bar{v}_{ib's't} \text{ for all } (b', s') \in \Omega_\kappa$$

- Probability of purchasing (b, s) is $s_{ibs}(\mathbf{p_t}, \mathbf{a_t}, \zeta_t) =$

$$\frac{\exp[\alpha_i(\mathbf{a_{bt}}, p_{bst}) + \psi_i(\mathbf{a_{bt}}, x_b) + \gamma_{bi}(\mathbf{a_t}) + \eta_i(\mathbf{z_{bs}}, \xi_b)]}{\exp(\zeta_{d0t}) + \sum_{(b',s')\in\Omega_\kappa} \exp[\alpha_i(\mathbf{a_{b't}}, p_{b's't}) + \psi_i(\mathbf{a_{b't}}, x_{b'}) + \gamma_{bi}(\mathbf{a_t}) + \eta_i(\mathbf{z_{b's'}}, \xi_{b'})]}$$

- Aggregate demand is:

$$s_{bs}(\mathbf{p_t}, \mathbf{a_t}, \zeta_t) = \int s_{ibs}(\mathbf{p_t}, \mathbf{a_t}) dF(\upsilon_i, d_i)$$

Impact of advertising on demand is flexible

- Brand advertising can be (even at individual level):
  - predatory with respect to some products and cooperative with respect to others
  - market expanding or contracting

$$\frac{\partial s_{ibst}}{\partial a_{bt}} = s_{ibst}\left(\tilde{\lambda}_{ibst} - \rho_i(1 - s_{i00t}) - \sum_{s' \in K_b}(\tilde{\lambda}_{ibs't} - \rho_i)s_{ibs't}\right)$$

$$\frac{\partial s_{ibst}}{\partial a_{b't}} = s_{ibst}\left(\rho_i s_{i00t} - \sum_{s' \in K_{b'}}(\tilde{\lambda}_{ib's't} - \rho_i)s_{ib's't}\right)$$

$$\frac{\partial s_{i00t}}{\partial a_{b't}} = -\, s_{i00t}\left(\rho_i(1 - s_{i00t}) + \sum_{s' \in K_{b'}}(\tilde{\lambda}_{ib's't} - \rho_i)s_{ib's't}\right)$$

where

$$\tilde{\lambda}_{ibst} = \lambda_i + \alpha_{1i} p_{sbt} + \psi_{1i} x_b$$

Potential distortionary effects of advertising

- Willingness to pay for better nutrient quality is potentially affected by advertising

$$WTP_{ibt} = \frac{\partial \bar{v}_{ibst} / \partial x_b}{\partial \bar{v}_{ibst} / \partial p_{bst}} = \frac{\psi_{0i} + \psi_{1i} \mathbf{a_{bt}}}{\alpha_{0i} + \alpha_{1i} \mathbf{a_{bt}}}$$

- Increases or decreases with $\mathbf{a_{bt}}$ depending on the sign of

$$\psi_{1i}\alpha_{0i} - \psi_{0i}\alpha_{1i}$$

Supply overview

- Multi-product firms compete by setting simultaneously two strategic instruments to maximize profits
  - prices and advertising expenditures
- Firms' problem is dynamic because
  - advertising today affects future demand and hence profits
- However because we consider an advertising ban, we don't have to solve dynamic model

Profit

- Multi-product firm j chooses (p_{bst}, e_{bt}) to maximize intertemporal profit:

$$\sum_{t=0}^{\infty} \beta^t \left[\sum_{(b,s) \in N_j^{bs}} (p_{bst} - c_{bst}) \, s_{bs} (\mathbf{p}_t, \mathbf{a}_t, \zeta_t) \, M_t - \sum_{b \in N_j^b} e_{bt} \right]$$

where

$$\mathbf{a}_{bt} = f(e_{bt}, e_{bt-1}, e_{bt-2}, ..., e_{b0})$$

N_j^{bs}: set of products owned by firm j
N_j^b: set of brands owned by firm j
c_{bst}: constant marginal cost
M_t: size of the potential market
e_{bt}: advertising expenditure

Price first order conditions

- Price first order conditions :

$$s_{bs}\left(\mathbf{p}_t, \mathbf{a}_t, \zeta_t\right) + \sum_{(b',s') \in N_j} \left(p_{b's't} - c_{b's't}\right) \frac{\partial s_{b's'}\left(\mathbf{p}_t, \mathbf{a}_t, \zeta_t\right)}{\partial p_{bst}} = 0$$

- ... we can identify marginal costs without solving for the full value function in the dynamic game
- Optimality conditions of entry, exit and advertising decisions not needed for identification of costs

Advertising Ban

- We can simulate the counterfactual equilibrium of a ban on advertising ($\mathbf{a}_t = 0$) using price first order conditions

$$s_{bs}\left(\mathbf{p}, \mathbf{0}, \zeta\right) + \sum_{(b',s') \in N_j} \left(p_{b's't} - c_{b's't}\right) \frac{\partial s_{b's'}\left(\mathbf{p}, \mathbf{0}, \zeta\right)}{\partial p_{bs}} = 0$$

  where

$$s_{bs}(\mathbf{p}, \mathbf{0}, \zeta) = \int s_{ibs}(\mathbf{p}, \mathbf{0}, \zeta) dF(\upsilon_i, d_i)$$

  is aggregate demand for product (b, s) when advertising is banned

- In more recent work Abi-Rafeh, Dubois, Griffith and O'Connell (2024) we show how to solve the full problem in advertising

Purchase data

- From Kantar/TNS Worldpanel
- June 2009 - October 2010
- Use information on a panel where we observe purchases both at home and on the go
  - all groceries brought into home, 161,513 transactions
  - all snacks bought for consumption outside the home, 99,636 transactions
- Transaction (barcode) level quantities, prices, characteristics
- Household and individual demographics

Food at home - 26 products in total

Brand	Size	Purchase Share	Price (£)
Pringles:	150-300g	1.34%	1.10
	300g+	5.54%	2.63
Walkers Regular:	150-300g	1.77%	1.25
	300g+	23.98%	2.77
Walkers Sensations:	150-300g	0.43%	1.26
	300g+	1.81%	2.52
Walkers Doritos:	150-300g	1.30%	1.21
	300g+	3.29%	2.47
Walkers Other:	<150g	0.69%	1.24
	150-300g	3.73%	1.77
	300g+	8.66%	3.17
Golden Wonder:	<150g	0.10%	1.28
	150-300g	0.25%	1.35
	300g+	1.15%	2.70
...			

Food on the go - 11 products in total

Brand	Size	Purchase Share	Price (£)
Walkers Regular	34.5g	27.16%	0.45
	50g	7.19%	0.63
Walkers Sensations	35g	2.04%	0.61
Walkers Doritos	50g	4.70%	0.54
Walkers Other	<30g	4.34%	0.45
	30g+	8.94%	0.61
KP	35g	0.83%	0.57
Golden Wonder:	<40g	3.08%	0.39
	40g+	1.09%	0.73
Other	<40g	17.57%	0.48
	40g+	20.01%	0.59
...			

Nutrient score

- government regulation uses a nutrient profile score
  - aggregates nutrient characteristics into a single score
  - lower score is healthier product

Brand	Nutrient score	Energy (kj per 100g)	Saturated fat (g per 100g)	Sodium (g per 100g)
Pringles	16	2160	6.31	0.62
Walkers Reg	10	2164	2.56	0.59
Walkers Sens	11	2023	2.16	0.71
Walkers Dor	12	2095	2.86	0.66
Walkers Oth	15	2020	2.50	0.82
KP	18	2158	5.87	0.85
GW	16	2101	4.01	0.92
Asda	15	2125	4.13	0.75
Tesco	15	2145	4.65	0.77
Other	12	2084	3.84	0.70

score is the sum of points, 1 point for each 335kJ per 100g, 1 for each 1g of saturated fat per 100g, and 1 for each 90mg of sodium per 100g

Advertising Expenditures

Monthly expenditure from AC Nielsen, all potato chips advertising appearing on TV, in press, on radio, on outside posters and internet

	Monthly expenditure (£100,000)			Total
	Mean	Min	Max	(06/09-10/10)
Pringles	4.50	0.00	10.14	76.54
Walkers Regular	4.97	0.00	18.29	84.47
Walkers Sensations	0.54	0.00	1.46	9.12
Walkers Doritos	1.75	0.00	8.25	29.67
Walkers Other	2.89	0.00	8.99	49.07
KP	2.09	0.00	8.49	35.60
Golden Wonder	0.08	0.00	0.80	1.34
Asda	0.01	0.00	0.23	0.23
Tesco	0.08	0.00	0.68	1.44
Other	1.58	0.00	5.74	26.83

Consumers Descriptive Statistics

Demographic group			Number of purchase occasions	
			food at home	food on-the-go
Composition	skill level	income		
HH no children	high	high	22721	14371
		medium	13178	8376
		low	13341	8219
	low	medium-high	10187	6667
		low	16147	8559
Pensioners			14384	6016
HH children	high	high	20426	12786
		medium	14292	8502
		low	7091	4494
	low	medium-high	15349	9549
		low	14397	8932
Child purchase				3165

- All parameters are allowed to vary across these demographics

Identification: price and advertising variations

- Price variation
  - longitudinal data, we see consumers buying in different stores, where menu of prices differ, assume store choice exogenous (conditional on controls)
  - time series variation of prices within product due to promotions
- Advertising variation
  - exposure varies due to idiosyncractic TV viewing behaviours
  - use control function (Blundell and Powell, 2004 and Petrin and Train, 2010) with advertising expenditure on ready-meals interacted with brand fixed effects as instruments; because brand advertising flows may be correlated with unobserved individual demand shocks

Advertising effects on brand demand

- Advertising leads to a reduction in consumer's sensitivity to price
- There are some spillover effects in advertising, e.g. one brand reducing it's advertising not only reduces it's own demand but also reduces demand of other products (advertising is cooperative, or market expanding)
  - this underlines the importance of allowing advertising to enter demand in a flexible way that does not unduly constrain the impact of advertising on demand a priori; if we had only included own brand advertising in the payoff function and omitted the competitor advertising effect the functional form assumptions would have ruled out cooperative advertising effects.

Willingness to pay for healthiness

Effect of advertising on willingness to pay for an increase in healthiness (a 1 point reduction in nutrient profiling score)

Measured as % of mean price relative to someone with zero advertising exposure

	Position in advertising exposure distribution		
Advertising:	10th pctile	Median	90th pctile
At home	-2.3%	-3.5%	-4.5%
On-the-go	-0.9%	-1.1%	-1.2%

Counterfactual

- Estimate marginal costs using supply model
- Simulate counterfactuals
  - no pricing response
  - with pricing response
  - check deviations of Nash equilibrium in product exits

Advertising ban: pricing response

- Banning advertising leads to toughening price competition
- The average price in the market falls by 9%
- Pricing response differs across firms and over products
  - The big advertisers (e.g. Walkers and Pringles) lower prices
  - For instance, Walkers reduces price of its most popular brand by the most, 34p (or 28%) reduction for the 150-300g pack, and 56p (or 20%) for the 300g+ pack
- Besides advertising ban, no products exit the market (keeping all products is a Nash equilibrium)

Advertising ban

	Post ban % change	
	No firm response	With firm response
Expenditure (£m)	-15.1	-13.6
	[-17.8, -12.7]	[-16.2, 111.2]
Quantity (mKg)	-15.2	-9.7
	[-17.9, -12.6]	[-11.8, -7.4]

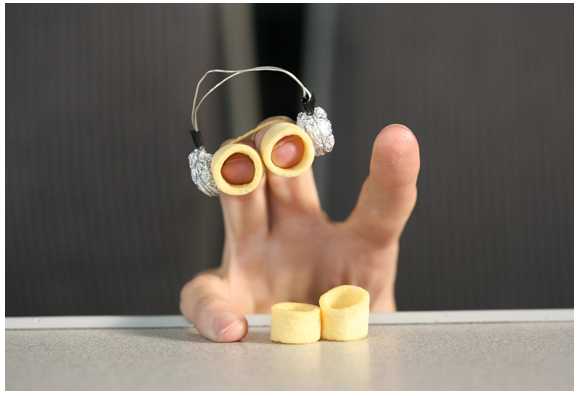
Advertising ban

	Advertising banned % change	
	no price response	with price response
Saturates	-16.3 [-18.1, -13.6]	-11.9 [-13.6, -9.7]
Salt	-15.4 [-17.4, -12.8]	-10.34.61 [-12.0, -7.8]
Saturates intensity	-1.2 [-1.7, -0.7]	-2.4 [-2.9, -2.0]
Salt intensity	-0.2 [-0.4, -0.01]	-0.6 [-0.8, -0.5]

Consumer welfare

- What impact on welfare?
- How we measure welfare depends on whether we view advertising as:
  - Informative about prices/characteristics (Stigler, 1961; Nelson, 1995)
  - A characteristic that consumers value (Stigler and Becker, 1977)
  - Persuasive (Marshall, 1921; Robinson, 1933; Kaldor, 1950)

Advertising for crisps



Consumer welfare: advertising as a characteristic

- If advertising is a characteristic, the payoff function represents the consumer's (indirect) utility function; the consumer makes decisions to maximize utility (standard revealed preference approach)
- Denote the expected utility in this case as

  $W_{it}(\mathbf{p}_t, \mathbf{a}_t)$

Consumer welfare: advertising distorts decisions

- If advertising is distorting, then consumer's "experience" utility differs from their decision utility (Kahneman et al. 1997)
- Their experience utility should be evaluated using non-distorted preference, ie. those they would have in the absence of advertising
- Denote expected "experience" utility as:

  $\widehat{W}_i(\mathbf{a_t}, \mathbf{p_t})$

Consumer welfare: advertising distorts decisions

- When advertising distorts decision making, welfare impact of advertising evaluated under preferences in absence of advertising
- Denote $\mathbf{p}^0$ a counterfactual price equilibrium with no advertising
- Welfare difference between the post and pre advertising ban is:

$$
\begin{aligned}
& W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - \widehat{W}_i\left(\mathbf{a_t}, \mathbf{p_t}\right) \\
= & W_i\left(\mathbf{0}, \mathbf{p_t}\right) - \widehat{W}_i\left(\mathbf{a_t}, \mathbf{p_t}\right) \quad \text{(choice distortion effect)} \\
+ & W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - W_i\left(\mathbf{0}, \mathbf{p_t}\right) \quad \text{(price competition effect)}
\end{aligned}
$$

where we use $\widehat{W}_i\left(\mathbf{0}, \mathbf{p}\right) = W_i\left(\mathbf{0}, \mathbf{p}\right)$

Consumer welfare

	Persuasive view	Characteristics view
Choice distortion effect (£m)	15.0	
	[14.2, 16.1]	
Characteristics effect (£m)		-23.2
		[-25.4, -20.4]
Price competition effect (£m)	3.7	3.7
	[3.1, 3.1]	[3.1, 3.1]
Total compensating variation (£m)	18.7	-19.5
	[17.7, 20.4]	[-21.3, -16.7]
Change in profits (£m)	-5.1	-5.1
	[-6.0, -3.7]	[-6.0, -3.7]
Total change in welfare (£m)	13.6	-24.6
	[12.7, 15.1]	[-27.0, -20.4]

Aggregate impact of ban

We find that in response to introduction of an advertising ban in potato chips markets:

- Advertising ban leads to substitution to healthier products
- At constant prices, quantity of potato chips purchased would decrease
- But stronger price competition leads to lower prices and thus an offsetting increase in quantity
- If advertising is viewed as distorting prices, total welfare would rise
- Welfare would decrease if advertising as a characteristic (assuming advertising affects only the inside goods)