Griliches Lectures

Lecture 3

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Motivation

Policy has the potential to improve welfare when consumption generates social costs; applies to "sin goods" - tobacco, alcoholic drinks, sugary drinks and other unhealthy foods (such as fast food)

- this motivates corrective taxes and regulations to availability, advertising, reformulation
- social costs include
  - externalities: second hand smoking, alcohol related crime, healthcare costs due to rising obesity
  - internalities: poor performance at school, future poor health, worse social and economic outcomes
- role of policy is to discourage socially costly consumption

Motivation

How effective are policies

- what the direct and indirect effects of policies?
- do they discourage socially costly consumption?
- what are the welfare implications? who gains and who loses?
- could we design better policies, that discourages socially cost consumption at lower cost?

Empirical approaches to learn about these questions ex ante

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

Lecture 3

- how do taxes and advertising interact?
- empirical approaches to learn about supply side dynamics

Motivation

Taxes are commonly levied on sin goods

- Alcohol, tobacco, sugary drinks ...

These markets typically

- have a few large multiproduct firms that sell differentiated products and often spend a lot on advertise
- advertising potentially affects demand both contemporaneously and into the future

Firms may respond to taxes by adjusting their advertising expenditures, meaning the introduction of a tax can have dynamic effects on the market equilibrium

- how important? what impact on the effectiveness of policy?

Abi-Rafeh, Dubios, Griffith and O'Connell (2023)
"The effects of sin taxes and advertising restrictions
in a dynamic equilibrium "

Abi-Rafeh, Dubios, Griffith and O'Connell (2023)

What is impact of tax, allowing for firms' advertising response?

How does a tax compare to advertising restrictions?

- build dynamic oligopoly model of firms' optimal price and advertising decisions
- show how role of advertising agencies reduces action space in dynamic game making it tractable to solve model
- estimate empirical model, use to compare effects of specific and ad valorem taxes and restrictions to advertising

Setting: cola segment of UK drinks market

How do we expect tax and advertising to interact

To gain intuition consider a simple monopoly example:

- Demand $Q(p, A)$; p: price, A: advertising
- Marginal cost $C = \underbrace{c}_{\text{fixed marginal cost}} + \underbrace{\tau}_{\text{tax}}$
- Cost of advertising: k
- The monopolist chooses price and advertising to

$$\max_{p,A}\{\underbrace{(p - C)}_{\text{markup:}\mu} Q(p, A) - kA\}$$

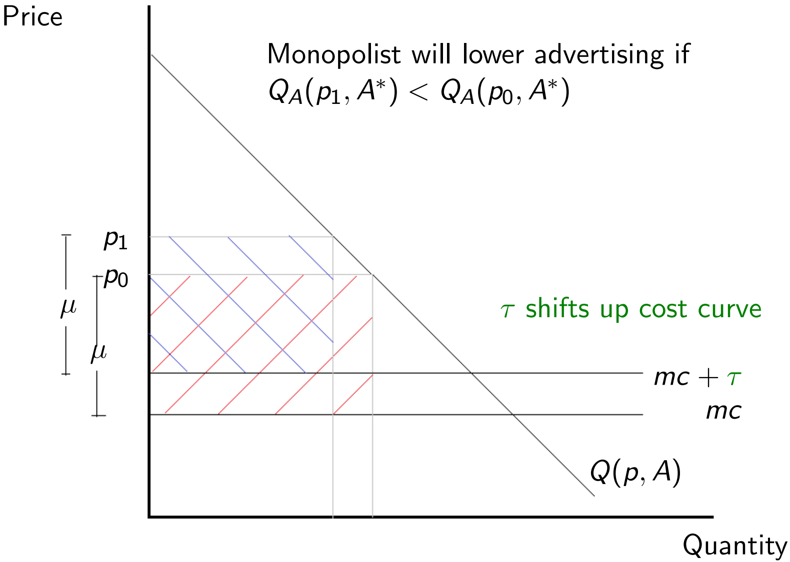
- the optimal advertising choice equates marginal revenue and cost

$$\mu Q_A(p, A) = k$$

How will monopolist change advertising?

- assume monopolist has fixed margin
  - tax increases price, firm moves up demand curve; if consumers more (less) responsive to advertising at this point then firm raises (lowers) advertising
- if monopolist also adjusts margin (price is a choice)
  - a second force at play; if firm raises its margin this increases the profitability of the marginal consumer and, all else equal, incentivises the firm to raise advertising (and visa versa)

Fixed margin monopolist



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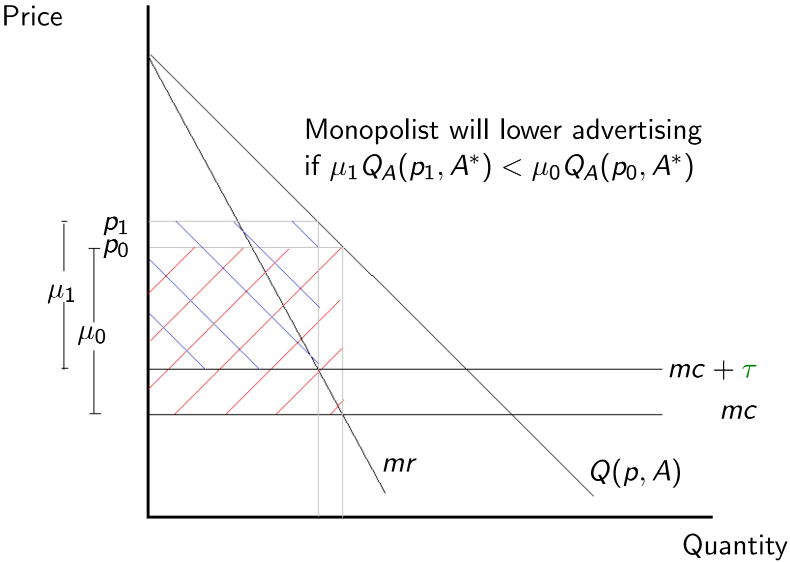
Margin adjustment



More generally ...

In simple monopoly example impact of tax on advertising depends on

- How sensitivity of demand to advertising changes along demand curve
- How tax impacts profitability of marginal consumer

In differentiated product oligopoly there will be additional forces:

- **Dynamic effects** due to long-last impact of advertising
- **Multi-product firm** with only subset of products subject to tax
- **Competitors'** actions will impact the firm's profits

For latter two, whether advertising steals market market share or leads to positive spillovers will be key

Model overview

Study the UK cola market

- Firms choose prices and advertising budgets
  - advertising affect demand today and into the future so that firm's choice is dynamic
- Advertising agencies act as intermediaries, choosing advertising spots
  - Reduce firms' problem from decision over 1000s of advertising spots, to tractable decision over advertising budget
- Consumers choose which (if any) product to buy
  - Their choice is influenced by their stock of advertising exposure
  - Depends on their TV viewing habits and placement of advertising spots

Purchase data

Kantar Purchase Panel

- household level scanner data, 2010-16
- households record all grocery transactions
- prices, quantities and characteristics at the household and product level
- longitudinal (follow the same households over time)
  - facilitates modeling consumer preference heterogeneity
- includes information on TV viewing behavior of household

The cola market: firms and brands

Firm	Brand	Market share	No. of products	Average price (£per liter)
Coca Cola Enterprises	Regular Coke	25.9%	15	0.82
	Diet Coke	34.8%	15	0.81
Pepsico	Regular Pepsi	7.6%	3	0.72
	Diet Pepsi	25.8%	5	0.73
Store brands	Regular store	2.4%	2	0.21
	Diet store	3.5%	2	0.21
All		100%	42	0.74

Advertising data

TV adverts from AC Nielsen

- Spot level data on all TV adverts over 2009-16
- over 1m adverts for cola (Coca Cola and Pepsi)
- Details of what was advertised, time slot, station, show
- Plus advertising expenditure

Shows | Stations | Time slots | Agencies | Temporal variation

Broadcaster Audience Research Board (BARB)

- Measure of advertising impressions for all adverts in 2015

Individual level advertising exposure

Exposure of individual i to advertising of brand b in week t is:

$$a_{ibt} = \sum_{k|t(k)=t} w_{ik} f(T_{bk})$$

where k is slot, w_{ik} is probability of viewing slot k, T_{bk} is advert duration and $f(.)$ is a concave function

- households asked whether they "regulary", "sometimes", "hardly ever", "never" watch most popular TV shows and alls stations and times
- use BARB data on population viewing in 2015 to estimate probability corresponding to each answer to get $\hat{w}$

Estimation of w_{ik}

Match between houshold media data (Kantar) and advert data (AC Nielsen)

Match	No. ads	%
Show	209,733	20
Station + time slot	483,180	46
Time slot only	352,267	34
Total	1,045,180	100

Match in 2015 with BARB data

			Expenditure (£)	
Match	No. ads	Mean TVR	Mean per ad	Sum
Show	35,481	.05337	214	7,584,502
Station + time slot	77,083	.01700	105	8,104,405
Time slot only	62,270	.00068	13	833,836

TVR: television rating values

We use the match with BARB to estimate $\hat{w}$

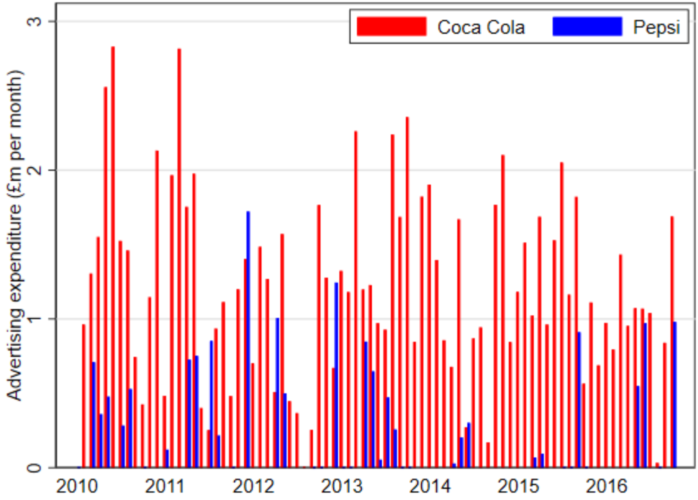
Brand advertising expenditure

Expenditure on brand b advertising in week t is:

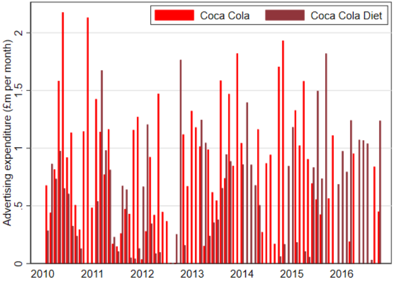
$$e_{bt} = \sum_{k|t(k)=t} \rho_k T_{bk}$$

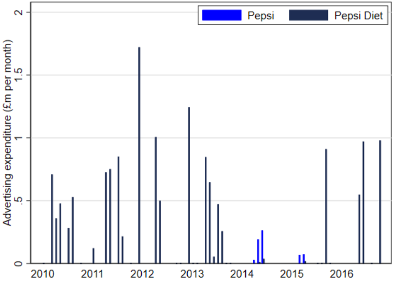
where ρ_k is the price of advertising during slot k

Monthly advertising expenditure



Monthly advertising expenditure





Model overview

Study the UK cola market

- Consumers choose which (if any) product to buy
  - choice is influenced by their stock of advertising exposure
  - depends on their TV viewing habits and placement of advertising spots
- Firms choose prices and advertising budgets
  - advertising affect demand today and into the future so that firm's choice is dynamic
- Advertising agencies act as intermediaries, choosing advertising spots
  - Reduce firms' problem from decision over 1000s of advertising spots, to tractable decision over advertising budget

The consumer's decision

Advertising today can affect consumers' choices into the future

Consumers accumulate stock of advertising exposure to each brand b:

$$\mathcal{A}_{ibt} = g(a_{ib0}, a_{ib1}, \ldots, a_{ibt-1})$$

Vector of consumer exposure stocks across brands

$$\mathcal{A}_{it} = (\mathcal{A}_{i1t}, \ldots, \mathcal{A}_{iBt})$$

the set of exposure stocks across consumers

$$\mathcal{A}_t = \{\mathcal{A}_{it}\}_{i \in I}$$

The consumer's decision

Choose among products $j = \{0, \ldots, J\}$, decision utility from product j:

$$U_{ijt} = u(\mathcal{A}_{it}, p_{jt}, \mathbf{x}_{jt}; \theta_i) + \epsilon_{ijt}$$

where p: price, $\mathbf{x}$ are product attributes, θ preferences, and ϵ_{ijt} an iid extreme value shock

The (i, j, t) choice probability is:

$$s_{ijt} = \frac{\exp(V\left(\mathcal{A}_{it}, p_{jt}, x_{jt}; \theta_i\right))}{\exp(V(\theta_i)) + \sum_{j'=1}^{J} \exp(V\left(\mathcal{A}_{it}, p_{j't}, x_{j't}; \theta_i\right))}$$

The firm's decision

Firm choose prices and advertising expenditures

Firm f's **flow** profits take the form:

$$\pi_f\left(\mathcal{A}_t, \mathbf{p_t}, \mathbf{e_t}\right) = \sum\nolimits_{j \in \mathcal{J}_f} \left(p_{jt} - c_{jt}\right) s_{jt}\left(\mathbf{p}_t, \mathcal{A}_t\right) M_t - \sum\nolimits_{b \in \mathcal{B}_f} (1 + \psi_b) e_{bt}$$

- c_{jt}: product j marginal cost
- ψ_b: advertising agency mark-up
- M_t: size of market
- e_{bt}: expenditure on advertising brand b

market share for product $j > 0$

$$s_{jt}\left(\mathbf{p_t}, \mathcal{A}_t\right) = \int\int \frac{\exp(V\left(\mathcal{A}_{it}, p_{jt}, x_{jt}; \theta_i\right))}{\exp(V(\theta_i)) + \sum_{j'=1}^{J} \exp(V\left(\mathcal{A}_{it}, p_{j't}, x_{j't}; \theta_i\right))} dF(\theta_i, \mathcal{A}_{it})$$

The firm's decision - pricing

We assume that

- firms simultaneously set prices to maximize profit (conditional on the distribution of advertising exposure stocks)
- prices directly impact current but not future flow profits

firm f's first order condition for period t prices is:

$$s_{jt}\left(\mathbf{p}_t, \mathcal{A}_t\right) + \sum\nolimits_{j' \in \mathcal{J}_f} \left(p_{j't} - c_{j't}\right) \frac{\partial s_{j't}\left(\mathbf{p}_t, \mathcal{A}_t\right)}{\partial p_{jt}} = 0$$

We assume prices are set in a Bertrand-Nash equilibrium, such that the set of price first order conditions hold for all f

The firm's decision - advertising

Firms simultaneously choose advertising budgets, e_{bt}, to maximize profits

- advertising has lasting effects into the future, so the problem is dynamic

Re-write the flow profit,

$$\tilde{\pi}_f\left(\mathcal{A}_t, \mathbf{e}_t\right) \equiv \pi_f\left(\mathcal{A}_t, p^*_{jt}\left(\mathcal{A}_t\right), \mathbf{e_t}\right)$$

where $p^*_{jt}\left(\mathcal{A}_t\right)$: optimal price given advertising exposure stocks

Firm's intertemporal profits,

$$\sum_{t=0}^{\infty} \beta^t \tilde{\pi}_f\left(\mathcal{A}_t, \mathbf{e}_t\right)$$

The firm's decision - advertising

We focus on Markov strategies

- for firm f, a strategy σ_f is a mapping between the current advertising exposure stock distribution and advertising expenditure for the brands it owns, $\sigma_f(\mathcal{A}_t) \equiv \left(\{e_{bt}\}_{b \in \mathcal{B}_f}\right)$
- each firm chooses its strategy given beliefs about competitors' strategies
- in a Markov Perfect Equilibrium, firms' beliefs are mutually compatible

Given other firms' strategies $\sigma_{-f}(\mathcal{A}_t)$, firm f solves the Bellman equation:

$$\pi_f^*(\mathcal{A}_t) = \max_{\{e_{bt}\}_{b \in \mathcal{B}_f}} \tilde{\pi}_f(\mathcal{A}_t, \mathbf{e}_t) + \beta \pi_f^*(\mathcal{A}_{t+1})$$

Oligopoly competition in price and advertising

- Dynamic oligopoly game because advertising has lasting impact on consumers preferences
- Action space for each multiproduct firm: prices of all products, advertising spots by brand on all TV channels, day, program and time of the day, by 30 seconds spot
- State space for each multiproduct firm: all actions (prices, ads, ..) of all firms in the past, current marginal costs and demand shocks
  $\rightarrow$ huge action and state spaces prohibit considering the estimation of Markov Perfect Equilibrium strategies of this dynamic game mapping state space to action space for each firm
- Unlikely (impossible) that firms solve such problem
- Firms use advertising agencies as intermediary to choose ad spots

The advertising agency

Firms delegate their choice of advertising slots to an advertising agency

- agency chooses slots to maximize exposure given a budget constraint

This captures important feature of the advertising market, and reduces firms' action space so dynamic oligopoly game is tractable

The agency chooses the set of slots, T_{bk}, to solve:

$$\max_{\{T_{bk}\}_k} \sum\nolimits_i \phi_{g(i)b} a_{ibt}$$

$$\text{s.t.} \sum\nolimits_{\{k|t(k)=t\}} \rho_k T_{bk} \leq e_{bt}.$$

where $\phi_{g(i)b}$ is the weight the firm assigns to the exposure of consumers belonging to demographic group g, and ρ_k is the price of advertising during slot k

The advertising agency

The first order condition of the agency's problem implies that the ratio of total marginal impacts during two advertising slots, k and k', is set equal to the ratio of the price of advertising during these slots:

$$\frac{\sum_i \phi_{g(i)b} w_{ik} f'(T_{bk})}{\sum_i \phi_{g(i)b} w_{ik'} f'(T_{bk'})} = \frac{\rho_k}{\rho_{k'}}.$$

- concavity of $f(.)$ means T^*_{bk} is a decreasing function of the price per viewer during slot k, $\frac{\rho_k}{\sum_i \phi_{g(i)b} w_{ik}}$
- we assume $f(T_{bk}) = T^\gamma$, agency problem implies log-linear relationship between price per impression and advert length (conditional on brand-time fixed effects)
- use BARB data to estimate $\hat{\gamma} = 0.642 \quad (0.001)$

Demand specification

We specify the form of the decision utility

- important that specification is rich enough to capture heterogeneity in different consumers responses to variation in price and advertising, how these responses are correlated, and how the impact of advertising of one product might affect demand of other products

We estimate the demand model separately by 12 demographic groups, denoted $d(i)$, based on the household type (household with children, working age household with no children, pensioner household) and within household type income quartiles

Our motivation for this is to control for demographic attributes advertisers may target

Demand specification

Decision utility function for advertised goods (Coca Cola and Pepsi):

$$U_{ijt} = \alpha_i p_{jr(i,t)t} + \beta_i^O \sinh^{-1}(A_{ib(j)t}) + \beta_{d(i)}^W \sinh^{-1}(A_{i-b(j)t}) + \beta_{d(i)}^X \sinh^{-1}(A_{i-f(j)t}) + \gamma_i \text{Sug}_j + \phi_{d(i)} \mathbf{Z}_{if(j)} + \eta_{ib(j)} + \chi_j + \xi_{b(j),\tau(t)} + \zeta_{b(j),r(i,t)} + \epsilon_{ijt}$$

three distinct effects of advertising on decision utility:

- an own-brand advertising effect, β_i^O
- a within-firm spillover effect, $\beta_{d(i)}^W$
- a cross-firm spillover effect, $\beta_{d(i)}^X$

advertising stock enters through inverse-hyperbolic sine function to capture diminishing returns of advertising exposure

Demand specification

Decision utility also depends on

- whether the product contains sugar (Sug_j)
- TV viewing behavior interacted with firm, $\mathbf{Z}_{if(j)}$
- consumer specific brand valuations, $\eta_{ib(j)}$
- product effects, χ_j
- time (year-quarter) varying brand effects, $\xi_{b(j),\tau(t)}$
- retailer varying brand effects, $\zeta_{b(j),r(i,t)}$

consumer specific preference coefficients on price, own-brand advertising, sugar and the brand effects

important to capture consumer substitution pattern across products

Advertising exposure

We assume consumers accumulate stock of advertising exposure to each brand b:

$$A_{ibt} = \sum_{s=0}^{t-1} \delta^{t-1-s} a_{ibs} = \delta A_{ibt-1} + a_{ibt-1}.$$

specification implies exposure to brand advertising two weeks ago contributes δ as much to the current stock of exposure as the same amount of exposure one week ago

We set $\delta = 0.9$

Identification of advertising effects

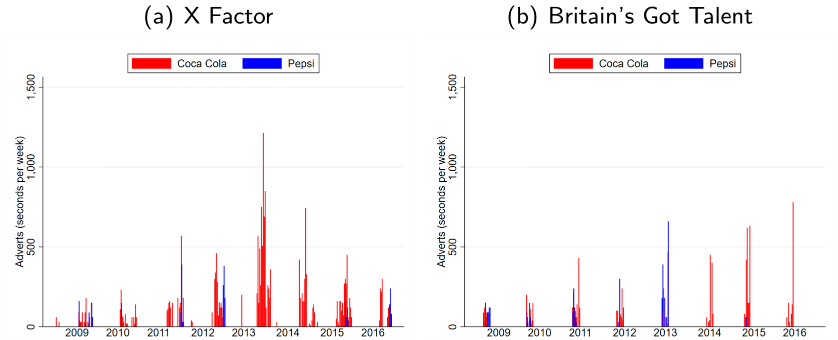
We control for

- brand-time-demographic group effects
- individual average viewing behavior for
  - weekly hours of viewing
  - genres: game shows, documentaries, drama, reality TV, sport and entertainment
  - stations
  - weekday/weekend$\times$time slot
  - all interacted with brand

Isolate differences in individual advertising exposure driven by variation in slots within demographic groups and show genre

Identification of advertising effects

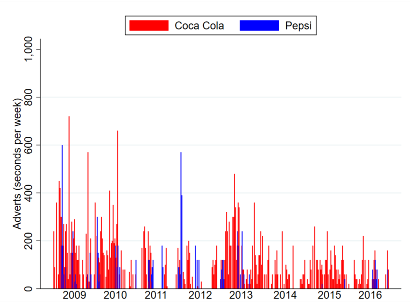
Example



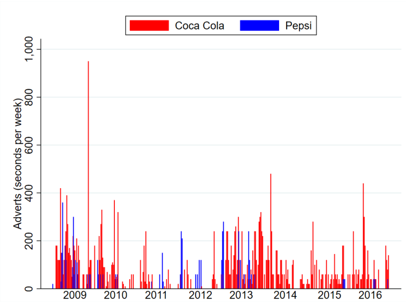
Identification of advertising effects

Example

(a) Frasier



(b) Everybody Loves Ramond



Preference distribution

We include random coefficients on price, own advertising, brand, sugary and outside option

- Model as joint normal, conditional on demographic group

Allow for correlation in preferences over price and advertising

- Allows for flexibility in cross derivative of market demand

Longitidunal micro data helps us pin down preference distribution

- For instance, all else equal, the higher the correlation in the price of chosen options within individual over time, the higher the implied spread parameter on price

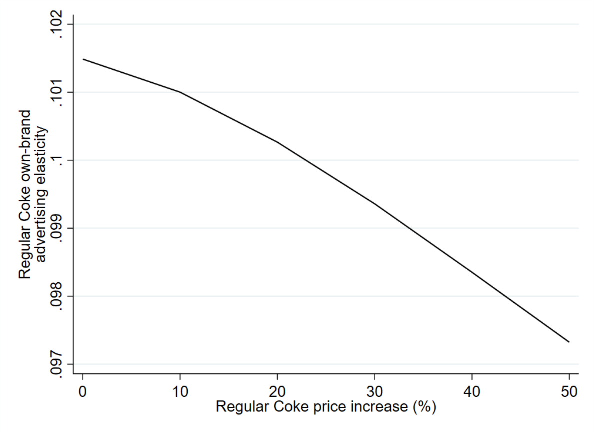
Brand price and advertising elasticities

impact of 1% increase in price/stock of exposure of brand in row on demand for brand in column

	Price elasticities				Advertising elasticities		
	Coke		Pepsi		Coke		Pepsi
	Regular	Diet	Regular	Diet	Regular	Diet	Diet
Regular Coke	**-2.210**	0.511	0.050	0.092	**0.115**	0.043	0.020
Diet Coke	0.378	**-2.192**	0.023	0.142	0.054	**0.110**	0.016
Regular Pepsi	0.210	0.128	**-1.842**	0.552	0.021	0.020	0.015
Diet Pepsi	0.110	0.232	0.157	**-1.679**	0.015	0.011	**0.057**
Regular Store	0.243	0.155	0.063	0.106	-0.021	-0.017	-0.011
Diet Store	0.130	0.276	0.031	0.170	-0.020	-0.021	-0.012
Regular outside	0.185	0.138	0.050	0.095	-0.020	-0.017	-0.009
Diet outside	0.104	0.236	0.027	0.152	-0.019	-0.021	-0.011

Impact of Regular Coke price level on advertising elasticity

illustrates the importance of allowing for correlation between price and advertising sensitivity



Dynamic supply-side

- Definition of state space ▸ Details
- State-to-state transition function ▸ Details
- Solve for Markov perfect equilibrium

Counterfactual policy simulations

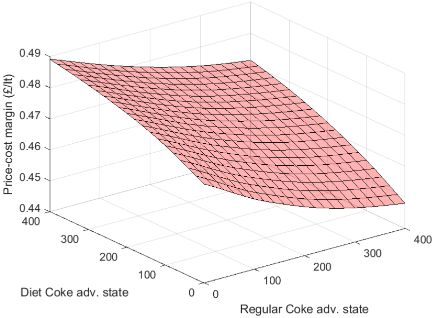
1. Solve for dynamic equilibrium with no policy in place
2. Simulate counterfactual equilibria
   - ban on advertising sugary colas (Coca Cola and Pepsi)
   - two alternative taxes applied to sugar-sweetened products
     - Volumetric tax: $p_c = p_f + \tau_s \times$ volume, with τ_s=£0.25/liter
     - Ad valorem tax: $p_c = p_f \times (1 + \tau_{ad})$, with τ_{ad} chosen to achieve same consumption reduction as under volumetric tax (holding advertising fixed)

Variation in Regular Coke Nash equilibrium

with Coca Cola advertising states

Price-cost margin

figure shows that Regular Coke margins are decreasing in the Regular Coke advertising state; this reflects the negative correlation in advertising and price sensitivity



Optimal policy function for Coca Cola Enterprises

model yields functions describing how equilibrium objects, such as prices, quantities, gross profits and advertising expenditures vary across the advertising states

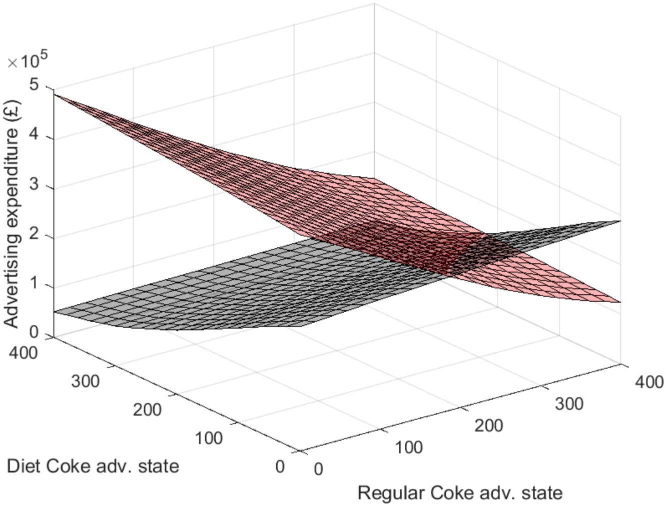
denote one of these functions $y(\{\mathbb{A}\}_b)$

and an equilibrium probability distribution across states, $p(\{\mathbb{A}\}_b)$

The average equilibrium outcome is then given by
$\bar{Y} = \int_{\{\mathbb{A}\}_b} y(\{\mathbb{A}\}_b) p(\{\mathbb{A}\}_b)$

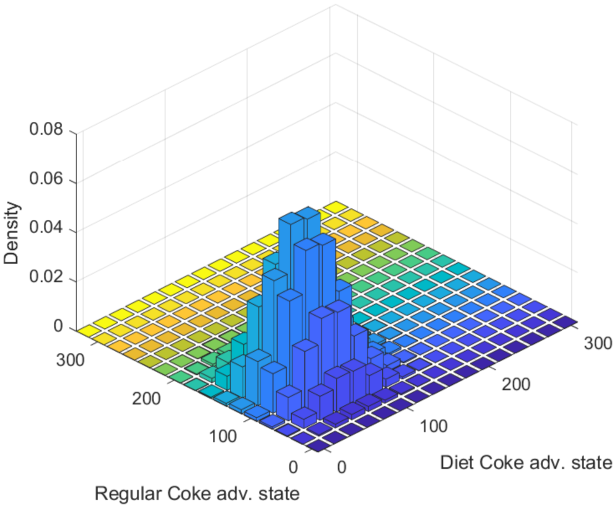
Optimal policy function for Coca Cola Enterprises

Advertising expenditure



Dark grey surface is Regular, lighter (red) surface is Diet Coca Cola

Equilibrium probability distribution for Coca Cola Enterprises



Aggregate impact of Advertising restriction

Δ quantity	Regular	-7.2%
	Diet	-2.8%
Δ price	Regular	0.4%
	Diet	-0.5%
Δ margin	Regular	0.9%
	Diet	-1.0%
Δ adv. exp.	Regular	-100.0%
	Diet	-16.2%
Δ profits		-1.2%
Compensating variation		-2.8%
Tax revenue		-
Δ surplus		-4.0%

Aggregate impact of Specific tax

		Fixed adv.	Incremental effect of	
			Eq. adv. response	Adv. restrict.
Δ quantity	Regular	-59.7%	-1.1%	-2.8%
	Diet	11.8%	-1.7%	-4.1%
Δ price	Regular	33.0%	0.1%	0.3%
	Diet	-1.4%	-0.1%	-0.3%
Δ margin	Regular	6.0%	0.2%	0.7%
	Diet	-2.9%	-0.2%	-0.7%
Δ adv. exp.	Regular	-	-56.8%	-100.0%
	Diet	-	-19.5%	-29.9%
Δ profits		-1.2%	-6.8%	-0.0%
Compensating variation		-2.8%	-7.6%	-1.0%
Tax revenue		-	4.7%	-0.1%
Δ surplus		-4.0%	-9.7%	-1.2%

Aggregate impact of Ad valorem tax

		Fixed adv.	Incremental effect of	
			Eq. adv. response	Adv. restrict.
Δ quantity	Regular	-59.5%	-1.6%	-2.8%
	Diet	11.4%	-2.9%	-4.6%
Δ price	Regular	43.0%	0.1%	0.2%
	Diet	-1.4%	-0.1%	-0.3%
Δ margin	Regular	-37.8%	0.1%	0.3%
	Diet	-2.9%	-0.3%	-0.6%
Δ adv. exp.	Regular	-	-80.0%	-100.0%
	Diet	-	-37.2%	-43.8%
Δ profits		-10.4%	-0.0%	-0.5%
Compensating variation		-7.6%	-1.6%	-2.7%
Tax revenue		7.7%	-0.3%	-0.5%
Δ surplus		-10.3%	-2.0%	-3.7%

Aggregate impact of counterfactual policies

		Adv. restrict.	Specific tax	Ad valorem tax
Δ quantity	Regular	-7.2%	-60.8%	-61.1%
	Diet	-2.8%	13.5%	14.3%
Δ price	Regular	0.4%	33.1%	43.1%
	Diet	-0.5%	-1.5%	-1.5%
Δ margin	Regular	0.9%	6.2%	-37.7%
	Diet	-1.0%	-3.1%	-3.2%
Δ adv. exp.	Regular	-100.0%	-56.8%	-80.0%
	Diet	-16.2%	-19.5%	-37.2%
Δ profits		-1.2%	-6.8%	-10.4%
Compensating variation		-2.8%	-8.6%	-9.2%
Tax revenue		-	4.6%	7.4%
Δ surplus		-4.0%	-10.9%	-12.3%

Summary

Estimate an equilibrium model in which firms compete through their pricing and advertising decisions

Show advertising has spillovers to other brands in market, and consumer sensitivity to advertising and price changes are positively correlated

Both a specific and ad valorem tax lead to lower advertising of taxed brands and modest change in advertising of non-taxed brands

- Larger response under ad valorem tax consistent with lower margins under this tax

Model predicts heterogeneous patterns of consumer response driven by differential advertising exposure

Advertising restriction leads to modest reduction in quantity

The end

Hopefully you've gained some ideas for how we can use economic models combined with data and econometrics to learn about the impacts of policies, and how we can design them better

Extra slides

Highest adv exp shows, 2010-2016 ▸ Back

	Both			Coca Cola			Pepsi		
	Exp (£m)	Rank	£/slot	Exp (£m)	Rank	£/slot	Exp (£m)	Rank	£/slot
The X Factor	6.2	1	1463	5.6	1	1480	0.6	2	1312
Coronation Street	4.3	2	1076	4.0	2	1128	0.4	6	723
Emmerdale	3.8	3	1086	3.3	3	1130	0.5	4	871
Hollyoaks	3.7	4	338	3.1	4	336	0.6	1	349
Britain's Got Talent	3.4	5	1716	2.9	5	1836	0.5	5	1208
I'm A Celebrity	2.5	6	2040	2.4	6	2096	0.1	21	1332
The Jeremy Kyle Show	2.4	7	217	2.1	7	216	0.3	12	227
Come Dine With Me	1.9	8	221	1.7	8	229	0.3	11	181
This Morning	1.8	9	180	1.6	9	181	0.2	18	171
Big Brother	1.6	10	296	1.4	10	297	0.3	9	294
Sunday 9Pm Movie	1.5	11	378	1.2	12	373	0.3	8	399
Friends	1.0	15	172	0.7	25	179	0.3	7	156
Uefa Champions League	0.9	18	596	0.4	45	483	0.5	3	708
The Simpsons	0.7	28	228	0.4	40	174	0.3	10	442

Highest adv exp stations, 2010-2016 ▸ Back

	Both			Coca Cola			Pepsi		
	Exp (£m)	Rank	£/slot	Exp (£m)	Rank	£/slot	Exp (£m)	Rank	£/slot
Itv1	53.4	1	466	47.2	1	473	6.3	1	417
C4	24.8	2	203	20.0	2	203	4.8	2	201
C5	11.4	3	165	9.4	3	165	2.0	3	168
Itv2	6.1	4	494	5.3	4	504	0.8	5	432
E4	4.4	5	268	3.6	5	262	0.8	4	295
Pick	2.4	6	228	2.1	6	227	0.3	8	236
Dave	1.5	7	170	1.3	7	171	0.2	11	164
Sky Sports	1.5	8	78	1.0	10	65	0.5	6	127
Sky 1	1.5	9	255	1.2	8	231	0.3	9	411
Quest	1.2	10	131	1.1	9	134	0.1	13	112
Film4	0.7	16	206	0.5	18	205	0.2	10	208
Itv4	0.6	17	173	0.2	35	171	0.4	7	174

Highest adv exp time slots, 2010-2016 Back

	Both			Coca Cola			Pepsi		
	Exp (£m)	Rank	£/slot	Exp (£m)	Rank	£/slot	Exp (£m)	Rank	£/slot
Week2000-2230	32.0	1	253	27.0	1	254	5.0	1	245
Week1800-2000	15.5	2	170	13.1	2	173	2.4	2	156
Sat2000-2230	13.2	3	431	11.6	3	443	1.7	4	367
Week2230-0100	11.2	4	87	8.9	4	84	2.3	3	100
Sun2000-2230	8.7	5	305	7.5	6	315	1.2	5	255
Sat1800-2000	8.6	6	363	7.9	5	385	0.6	7	212
Week1600-1800	5.1	7	108	4.4	7	110	0.8	6	96
Week0930-1200	4.6	8	61	3.9	8	62	0.6	8	53
Week0600-0930	3.9	9	49	3.4	9	50	0.5	11	44
Sun1800-2000	3.5	10	191	3.0	10	198	0.5	12	155
Sat2230-0100	2.5	12	97	2.0	12	93	0.5	9	118
Sun1600-1800	1.5	16	116	1.0	16	96	0.5	10	200

State space ▸ Back

Payoff relevant state variable is $\mathcal{A}_t$, the joint distribution of brand exposure in the population

Assume firms:

- Use mean stock, $A_{bt} = \mathbb{E}[A_{ibt}]$ as state variable in dynamic game
- And they expect all quantiles of long-run average stock distribution to scale in A_{bt}

Leads to very little prediction error:

$$\mathbb{E}[q_{jt}(\mathbf{p}_t, \mathcal{A}_t)] - \tilde{q}_{jt}(\mathbf{p}_t, \mathbf{A}_{bt})$$

State-to-state transitions ▸ Back

Transition function specifies probability over next period's advertising stock, given its current value and expenditure, $f(A_{bt+1}|A_{bt}, e_{bt})$ We

estimate:

$$A_{bt+1} - \delta A_{bt} = \lambda e_{bt}^{\gamma} + \nu_{bt}$$

As $T_{bk}^{*} = g(\mathbf{w}_k, \rho_k)e_{bt}^{\gamma}$, $\lambda = \mathbb{E}[g(\mathbf{w}_k, \rho_k)]$

We use a discrete grid for A_{bt}, $\{A_1, \ldots, A_K\}$, where:

$$\mathbb{Pr}(A_{bt+1} = A_{k'}|A_{bt} = A_k, e_{bt}) = \int_{A'_{k-1}}^{A_{k'}} f_{\nu}(A_{bt+1} - \delta A_k - \lambda e_{bt}^{\gamma}) \frac{A_{bt+1} - A_{k-1}}{A_{k'} - A_{k'-1}} dA_{bt+1} + \int_{A'_k}^{A_{k'+1}} f_{\nu}(A_{bt+1} - \delta A_k - \lambda e_{bt}^{\gamma}) \frac{A_{k'+1} - A_{bt+1}}{A_{k'+1} - A_{k'}} dA_{bt+1}$$