The impact of banning advertising on the market for crisps

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November 2012

Motivation

- Issue of growing obesity and diet related health disease across developed world
- Many policies proposed/introduced
  - Education and information campaigns
  - Fiscal measures
  - Regulations
- One is banning junk food advertising
  - UK currently bans advertising of foods high in fat, salt or sugar during children's programs
  - The Disney Channel plans to ban all junk food adverts

Contribution of this paper

- We investigate the consequences of banning advertising for crisps
  - Market with annual revenue in UK of £2bn
- We estimate a model of consumer demand for crisps
- And we model firms as competing by setting two strategic variables:
  - Advertising expenditures for their brands
  - Prices for their products
- We estimate the model using individual transaction level purchase data and detailed advertising data
- And simulate the impact of an advertising ban, allowing for:
  - Flexible demand responses
  - And the equilibrium pricing response of firms

Impact of advertising

- We would expect, ceteris paribus, that more advertising of a brand will increase demand for the brand
- It may lead to demand for other brands
  - increasing - in which case advertising is *cooperative*
  - decreasing - in which case advertising is *predatory*
- It may also cause the market size to:
  - expand (possible under either cooperative or predatory advertising)
  - contract (only possible in the case where advertising is predatory)
- But overall impact on advertising ban will also depend on strategic (pricing) response of firms

Consumer demand

Overview

- In crisps market:
  - Consumers tend to buy at most, one product at a time
  - There are many differentiated products available
- We model demand using a discrete choice model (mixed logit), in which:
  - The indirect utility of a given product is a function of the product's observed and unobserved characteristics
- Consumer's choice sets include crisp products available to him, plus the outside option of not consuming crisps
- Consumer is assumed to select option that yields highest realised utility

Consumer demand

Utility from inside options

Utility consumer i on purchase occasion τ obtains from product n takes the form:

$$v_{in\tau} = \alpha_i p_{n\tau} + \lambda_i a_{nt} + \rho_i \left(\sum_{l \neq n} a_{lt} \right) + \psi_i x_n + \eta_{in} + \epsilon_{in\tau}$$

$p_{n\tau}$ is the price of product n on purchase occasion τ
a_{nt} is the stock of advertising for product n in period t
x_n are other observed product characteristics
η_{in} are the consumers valuation of the product's unobserved characteristics
$\epsilon_{in\tau}$ is an iid type I extreme value random deviate

Consumer demand

Utility from outside option

Utility from outside option (of choosing a snack other than crisps) is given by:

$$v_{i0\tau} = \eta_{i0} + \epsilon_{i0\tau}$$

Consumer demand

Market shares

The probability that consumer i on purchase occasion τ chooses product n is

$$s_{in}(\mathbf{p}_\tau, \mathbf{a}_t) = \frac{\exp\left[\alpha_i p_{n\tau} + \lambda_i a_{nt} + \rho_i \left(\sum_{l \neq n} a_{lt}\right) + \psi_i x_n + \eta_{in}\right]}{\psi_{0n} + \sum_{k=1,..,N} \exp\left[\alpha_i p_{k\tau} + \lambda_i a_{kt} + \rho_i \left(\sum_{l \neq k} a_{lt}\right) + \psi_i x_k + \eta_{ik}\right]}$$

And the market share of product n in market t is:

$$S_n(\mathbf{p}_t, \mathbf{a}_t) = \int s_{in}(\mathbf{p}_t, \mathbf{a}_t) dF(\alpha_i, \lambda_i, \psi_{ni}, \eta_{in})$$

Impact of advertising on demand

- At the individual level the advertising cross semi-elasticity is:

$$\frac{\partial \ln s_{in\tau}}{\partial a_{kt}} = -((\lambda - \rho)s_{ik} - \rho s_{i0})$$

- So in the most intuitive case when $\lambda > 0$ and $\lambda > |\rho|$, advertising is predatory (so $\partial \ln s_{n\tau}/\partial a_{kt} < 0$) if:

$$\rho < \frac{s_{ik}}{s_{ik} + s_{i0}}\lambda$$

Supply

Overview

- We model firms as competing using two strategic instruments
- In each market (month) they simultaneously set prices and advertising budgets to maximise their profits
- We assume a constant market marginal cost for each product, c_{nt}
- We allow for persistence in the affect of advertising on demand
  - For each of their products, firms choice their monthly advertising budget, b_{nt}
  - But demands depend on the stock of advertising a_{nt}, where

$$a_{nt} = (1 - \delta) a_{nt-1} + b_{nt}$$

- Decisions over today's advertising budget will therefore affect future profits

Supply

Each period t, firms $j \in J$ choose (p_{nt}, b_{nt}) for $n \in N_j$ to:

$$\pi_j^*(a_{t-1}) = \{ \max_{(p_{nt}, b_{nt})} \sum_{n \in N_j} (p_{nt} - c_{nt}) S_n(p_t, a_t) M_t - b_{nt} \} + \delta \pi_j^*(a_t)$$

N_j are the set of products owned by firm j
a_{nt} and b_{nt} are the stock and flow of advertising for product n at time t, with

$$a_{nt} = (1 - \delta) a_{nt-1} + b_{nt}$$

c_{nt} is the marginal cost of product n in market t
M_t is the size of the potential market

Supply side

First order conditions

Price:

$$S_n(\mathbf{p}_t, \mathbf{a}_t) + \sum_{k \in N_j} (p_{kt} - c_{kt}) \frac{\partial S_k(\mathbf{p}_t, \mathbf{a}_t)}{\partial p_{nt}} = 0$$

- We estimate S_{nt} and $\frac{\partial S_{kt}}{\partial p_{nt}}$, and observe p_t
- Assuming p_t is the equilibrium price vector, we can infer c_t

Supply side

First order conditions

Price:

$$S_n(\mathbf{p}_t, \mathbf{a}_t) + \sum_{k \in N_j} (p_{kt} - c_{kt}) \frac{\partial S_k(\mathbf{p}_t, \mathbf{a}_t)}{\partial p_{nt}} = 0$$

Advertising:

$$\sum_{k \in N_j} (p_{kt} - c_{kt}) \frac{\partial S_k(\mathbf{p}_t, \mathbf{a}_t)}{\partial a_{nt}} - 1 + \delta \frac{\partial \pi_j^*(a_t)}{\partial a_{nt}} = 0$$

Simulating an advertising ban

Counterfactual pricing equilibrium is defined as the vector $\mathbf{p}_t^*$ such that:

$$S_n(\mathbf{p}_t^*, \mathbf{0}) + \sum_{k \in N_j} (p_{kt}^* - c_{kt}) \frac{\partial S_k(\mathbf{p}_t^*, \mathbf{0})}{\partial p_{nt}} = 0$$

for all $j \in J$

Purchase and price data

- Data on panel of around 4000 UK household over 2009-10
- Each households records all food purchase made and brought into the home (“Food in” purchases)
- In addition each household has at least one member who records purchases made for consumption outside the homes (“Food out” purchases)
- Data contain information on:
  - Price, quantity, store of individual purchase/barcodes
  - Product and household characteristics

Food in vs. Food out

- The menu of brands on offer in food in and food out purchase occasions is the same
- In food in occasions, consumers tend to by multi packs
  - Purchase is for future consumption
- In food out occasions, consumers tend to by single packs
  - Purchase is for immediate consumption
- We treat multi and single packs of the same brand as different products
- We constrain the choice sets of the two different purchase occasions

Market shares

Firm	Brand	Food in (Multi pack)	Food out (Single pack)
Walkers	*All brands*	55.64%	72.56%
	Wk - Reg	26.03%	45.83%
	Wk - Sens	3.34%	1.82%
	Wk - Dor	5.05%	4.67%
	Wk - Quav	4.20%	5.57%
	Wk - Wot	3.16%	1.40%
	Wk - Oth	13.86%	13.27%
Total		100.00%	100.00%

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	Wk - Oth	13.86%	13.27%
Procter & Gamble	Pringles	9.91%	0%
United Biscuits	*All brands*	19.49%	22.92%
	KP - Hula	6.05%	4.23%
	KP - McCoys	5.41%	10.63%
	KP - Skips	2.34%	0.71%
	KP - Oth	5.69%	7.35%
Tayto	*All brands*	0%	4.52%
	GW	0%	2.62%
	Tat - Oth	0%	1.90%
Asda		5.20%	0%
Tesco		9.76%	0%
Total		100.00%	100.00%

Unit price - £/Kg

Brand	Food in (Multi pack)	Food out (Single pack)
Wk - Reg	6.88	13.06
Wk - Sens	7.04	13.11
Wk - Dor	5.44	12.70
Wk - Quav	9.91	25.24
Wk - Wot	8.95	21.16
Wk - Oth	8.74	16.43
Pringles	6.45	.
KP - Hula	5.20	13.05
KP - McCoys	5.10	11.21
KP - Skips	8.61	22.52
KP - Oth	5.74	12.33
GW	.	11.01
Tat - Oth	.	17.01
Asda	5.45	.
Tesco	5.01	.
Total	6.74	14.12

Advertising data

- Data on advertising expenditure by brand and month
- Includes all crisps advertising appearing on TV, in press, on radio, on outside billboards and on the internet
- We compute the stock of advertising

$$a_{nt} = (1 - \delta) a_{nt-1} + b_{nt}$$

currently assume $\delta = 0.25$

Total advertising in 2009

Brand	Advertising expenditure (£m)
Walkers Regular	4.580
Walkers Sensations	1.182
Walkers Doritos	2.339
Walkers Quavers	0
Walkers Wotsits	0
Walkers Other	2.627
Pringles	3.242
KP Hula Hoops	0.809
KP McCoys	0.860
KP Skips	0
KP Others	0
Golden Wonder	0.002
Tat Others	0.004
Asda	0.175
Tesco	0.068
Total	15.888

Demand estimates

Product characteristics

We allow indirect utility to depend on:

- Price
  - Observed heterogeneity
    - Banded household income
    - Food in vs. food out
  - Unobserved heterogeneity
    - Log normally distributed random coefficient
- Advertising stock - both of product and the sum of advertising on other products
- Pack size
- Multi vs. single pack
- Brand dummies (capturing unobservable characteristics)
  - Unobserved heterogeneity
    - Normally distributed random coefficient

Parameter estimates

Price effect

	Coefficient estimate		Implied parameter
	Coefficient	Stand. error	distribution
Parameters of random distribution			
Mean	-0.8647	0.0358	-0.4377
Standard deviation	0.2773	0.0144	0.1189
Interaction terms			
Food out	0.1786	0.0075	-0.2591
Middle income	0.0202	0.0099	-0.4175
High income	0.0319	0.0065	-0.4058

Estimated on random sample of 15,000 purchases

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Parameter estimates

Other variables

	Mean coef.	Stand. error	Stand. dev.	Stand. error
Own adv. (λ)	0.1145	0.0332		
Comp. adv. (ρ)	0.0121	0.0192		
Pack size	-2.3272	0.3615		
Multi pack	0.1493	0.0661		
WK sen	-0.9105	0.1116		
WK dor	-2.2601	0.0933		
WK qua	-1.9910	0.0721	0.8531	0.0727
WK wot	-0.3731	0.0986		
WK oth	-1.3961	0.1098		
Pringles	-0.4740	0.0473	0.6681	0.0144
KP holah	-2.2949	0.0916		
KP mccoy	-1.9548	0.0860	1.2309	0.0585
KP skips	-2.2486	0.1339		
KP other	-2.1614	0.0936		
Golden w	-3.6747	0.2123	1.3789	0.1625
Taty oth	-3.3020	0.2153		
Asda	-2.3264	0.1049		
Tesco	-1.8459	0.0915		
Outside	-1.2152	0.1602		

Estimated on random sample of 15,000 purchases

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Price elasticities

Food in (multi) products

	Wk - Reg	Wk - Dor	Wk - Quav	Wk - Oth	KP - Hula	KP - McCoys	KP - Oth
Wk - Reg	**-2.052**	0.058	0.125	0.187	0.040	0.058	0.044
Wk - Dor	0.380	**-2.060**	0.122	0.185	0.041	0.059	0.044
Wk - Quav	0.367	0.055	**-3.342**	0.191	0.038	0.056	0.042
Wk - Oth	0.373	0.056	0.130	**-2.776**	0.039	0.057	0.043
KP - Hula	0.222	0.034	0.072	0.109	**-1.943**	0.165	0.123
KP - McCoys	0.222	0.034	0.072	0.109	0.113	**-1.866**	0.123
KP - Oth	0.223	0.034	0.072	0.109	0.113	0.164	**-1.908**
Outside	0.104	0.017	0.029	0.047	0.020	0.029	0.021

(i, j) gives percent change in demand for product i with respect to a 1 percent change in price of product j

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Price elasticities

Food out (single) products

	Wk - Reg	Wk - Dor	Wk - Quav	Wk - Oth	KP - Hula	KP - McCoys	KP - Oth
Wk - Reg	**-1.937**	0.052	0.072	0.240	0.034	0.053	0.052
Wk - Dor	0.465	**-2.119**	0.079	0.259	0.037	0.059	0.056
Wk - Quav	0.354	0.044	**-2.515**	0.203	0.030	0.044	0.038
Wk - Oth	0.436	0.053	0.075	**-2.144**	0.034	0.053	0.052
KP - Hula	0.285	0.035	0.051	0.159	**-2.059**	0.161	0.153
KP - McCoys	0.287	0.036	0.048	0.160	0.104	**-1.884**	0.158
KP - Oth	0.263	0.031	0.039	0.145	0.092	0.146	**-1.874**
Outside	0.186	0.020	0.015	0.098	0.021	0.036	0.046

(i, j) gives percent change in demand for product i with respect to a 1 percent change in price of product j

Advertising semi-elasticities

Food in (multi) products

	Wk - Reg	Wk - Dor	Wk - Quav	Wk - Oth	KP - Hula	KP - McCoys	KP - Oth
Wk - Reg	**9.070**	0.221	0.132	-0.157	0.301	0.199	0.278
Wk - Dor	-1.104	**10.474**	0.166	-0.120	0.321	0.221	0.300
Wk - Quav	-1.294	0.158	**10.252**	-0.283	0.238	0.133	0.215
Wk - Oth	-1.225	0.188	0.074	**10.011**	0.268	0.165	0.246
KP - Hula	-0.444	0.350	0.303	0.134	**10.165**	-0.346	-0.123
KP - McCoys	-0.442	0.352	0.305	0.137	-0.063	**9.883**	-0.119
KP - Oth	-0.445	0.352	0.305	0.136	-0.062	-0.339	**10.108**
Outside	-0.609	-0.281	-0.285	-0.356	-0.297	-0.340	-0.306

(i, j) gives percent change in demand for product i with respect to a £1m increase in advertising of product j

Advertising semi-elasticities

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Advertising semi-elasticities

Food out (single) products

	Wk - Reg	Wk - Dor	Wk - Quav	Wk - Oth	KP - Hula	KP - McCoys	KP - Oth
Wk - Reg	**8.430**	0.168	0.150	-0.760	0.261	0.136	0.141
Wk - Dor	-1.981	**10.423**	0.171	-0.857	0.292	0.154	0.123
Wk - Quav	-2.607	-0.049	**9.866**	-1.327	0.052	-0.092	-0.080
Wk - Oth	-1.884	0.157	0.126	**9.422**	0.252	0.124	0.123
KP - Hula	-1.088	0.297	0.269	-0.372	**10.153**	-0.461	-0.540
KP - McCoys	-1.009	0.329	0.317	-0.315	-0.035	**9.823**	-0.502
KP - Oth	-0.749	0.330	0.337	-0.151	0.029	-0.292	**9.878**
Outside	-1.075	-0.273	-0.239	-0.752	-0.276	-0.342	-0.607

(i, j) gives percent change in demand for product i with respect to a £1m increase in advertising of product j

Marginal cost

Brand	Pack type	Price (£/Kg)	Cost(£/Kg)	Margin
Wk - Reg	Multi	6.91	2.67	0.61
	Single	13.71	4.60	0.66
Wk - Dor	Multi	6.06	1.92	0.68
	Single	13.23	3.58	0.73
Wk - Quav	Multi	9.99	5.37	0.46
	Single	25.58	10.95	0.57
Wk - Oth	Multi	8.39	3.97	0.53
	Single	11.33	3.04	0.73
KP - Hula	Multi	5.64	2.20	0.61
	Single	13.55	5.79	0.57
KP - McCoys	Multi	5.01	1.63	0.68
	Single	11.66	4.44	0.62
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Wk - Dor	Multi	6.06	1.92	0.68
	Single	13.23	3.58	0.73
Wk - Quav	Multi	9.99	5.37	0.46
	Single	25.58	10.95	0.57
Wk - Oth	Multi	8.39	3.97	0.53
	Single	11.33	3.04	0.73
KP - Hula	Multi	5.64	2.20	0.61
	Single	13.55	5.79	0.57
KP - McCoys	Multi	5.01	1.63	0.68
	Single	11.66	4.44	0.62
KP - Oth	Multi	5.49	2.07	0.62
	Single	9.04	3.13	0.65

Simulation

	Initial		No pricing response		New equilibrium		
			Percent change in		Percent change in		
	Share	Advertising intensity	Share	Profits	Price	Share	Profits
Walkers	26.23%	0.47					
Procter & Gamble	1.54%	1.83					
United Biscuits	9.96%	0.11					
Tatyo	0.87%	0.00					
Asda	1.24%	0.00					
Tesco	2.03%	0.05					
Outside	58.13%	.					

Simulation

	Initial		No pricing response		New equilibrium		
			Percent change in		Percent change in		
	Share	Advertising intensity	Share	Profits	Price	Share	Profits
Walkers	26.23%	0.47	-7.19%	-6.48%			
Procter & Gamble	1.54%	1.83	-17.81%	-17.81%			
United Biscuits	9.96%	0.11	-1.24%	-0.80%			
Tatyo	0.87%	0.00	1.34%	1.42%			
Asda	1.24%	0.00	-1.95%	-1.95%			
Tesco	2.03%	0.05	-2.41%	-2.40%			
Outside	58.13%	.	4.03%	.			

Simulation

	Initial		No pricing response		New equilibrium		
			Percent change in		Percent change in		
	Share	Advertising intensity	Share	Profits	Price	Share	Profits
Walkers	26.23%	0.47	-7.19%	-6.48%	-5.35%	-1.03%	-6.38%
Procter & Gamble	1.54%	1.83	-17.81%	-17.81%	-18.01%	-0.19%	-18.44%
United Biscuits	9.96%	0.11	-1.24%	-0.80%	-2.28%	0.37%	-1.38%
Tatyo	0.87%	0.00	1.34%	1.42%	-0.46%	0.66%	0.88%
Asda	1.24%	0.00	-1.95%	-1.95%	-3.20%	0.24%	-2.70%
Tesco	2.03%	0.05	-2.41%	-2.40%	-3.57%	0.21%	-3.16%
Outside	58.13%	.	4.03%	.	3.48%	.	

Summary

- Estimate model of demand and supply in market for crisps using transaction level data
- Use model to simulate counterfactual equilibrium in which advertising is banned
- Very preliminary results suggest:
  - Policy reduces overall crisps demand by 5%
  - Firms that advertise a lot reduce price, other firms increase prices

On going work

- Allow for more observable heterogeneity (e.g. different impact for those with kids)
- Allow for more flexibility in advertising effect
  - Allow it to influence price sensitivity directly
- Different supply side model
  - Collusion in price, competition in advertising
- Consider other experiments - e.g. tax on advertising