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Abstract

Restricting advertising is one way governments seek to reduce consumption of potentially harmful goods. There have been increasing calls to apply a similar policy to the junk food market. The effect will depend on how brand advertising influences consumer demand, and on the strategic pricing response of oligopolistic firms. We develop a model of consumer demand and dynamic oligopoly supply in which multi-product firms compete in prices and advertising budgets. We model the impact of advertising on demand in a flexible way, that allows for the possibility that advertising is predatory or cooperative, and we consider how market equilibria would be impacted by an advertising ban. In our application we apply the model to the potato chip market using transaction level data. The implications of an advertising ban for consumer welfare depend on the view one takes about advertising. In the potato chip market advertising has little informational content. The advertising may be a characteristic valued by consumers, or it may act to distort decision-making. We quantify the welfare impacts of an advertising ban under alternative views of advertising, and show that welfare conclusions depend on which view of advertising the policymaker adopts.

Keywords: advertising, demand estimation, welfare, dynamic oligopoly

JEL classification: L13, M37

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1 Introduction

In this paper, we study the welfare consequences of a ban on advertising. We develop a model of consumer demand and oligopoly supply in which multi-product firms compete in prices and advertising budgets. We allow advertising to have a flexible impact on demand and for past advertising to influence current demand, which means firms play a dynamic game. We use the model to simulate counterfactual market equilibria in which advertising is banned. The effect of a ban on consumer welfare depends on the view one takes about advertising. In our empirical application we focus on the policy relevant application of considering an advertising ban in the junk food market. Most advertising in such markets is not informative, involving celebrity endorsements of established brands. In our assessment of the consumer welfare impact of a ban we therefore consider the view of advertising as a characteristic valued by consumers and the alternative view that advertising persuades consumers to make choices that are inconsistent with their underlying preferences. Overall assessment of the welfare consequences of banning advertising depends on which of these two views of advertising one adopts.

Advertising is regulated in many markets, for example in the cigarette and tobacco market, with the aim of reducing consumption.[1] Attention has recently turned to using a similar policy tool to reduce the consumption of junk foods. Most notably the medical literature has called for restrictions on advertising; for example, in a well cited paper, Gortmaker et al. (2011) state that, "marketing of food and beverages is associated with increasing obesity rates", citing work by Goris et al. (2010), and say that it is especially effective among children, citing National Academies (2006) and Cairns et al. (2009).[2] The aim of these interventions is to reduce consumption of junk foods, however, the economics literature does not point to such a clear result. A ban on advertising could lead the market to expand or to contract. Advertising may be predatory, in which case its effect is to steal market share of rival products, or it might be cooperative, so that an increase in the advertising of one product increases demand for other products (Friedman (1983)). The impact on total market demand depends on the relative importance of these two effects.[3] In addition, firms are likely to respond to a ban on advertising by adjusting their prices, as the equilibrium prices with advertising are unlikely to be the same as in an equilibrium when advertising is not permitted.

[1] In other markets, such as pharmaceuticals and some professional services, the aim is more focused on consumer protection.

[2] In the UK regulations ban the advertising of foods high in fat, salt or sugar during children's programming (see http://www.bbc.co.uk/news/health-17041347) and there have been recent calls to extend this ban (see http://www.guardian.co.uk/society/2012/sep/04/obesity-tv-junk-food-ads). In the US the Disney Channel has plans to ban junk food advertising (http://www.bbc.co.uk/news/world-us-canada-18336478).

[3] For example, Rojas and Peterson (2008) find that advertising increases aggregate demand for beer; while Anderson et al. (2012) show that comparative advertising of pharmaceuticals has strong business stealing effects and is detrimental to aggregate demand. Other papers show that regulating or banning advertising has led to more concentration, for example Eckard (1991), for cigarettes and Sass and Saurman (1995), for beer. Motta (2013) surveys numerous other studies.

We apply our model to the market for potato chips, which are an important source of junk calories; we use novel data on purchases made both for consumption at home and purchases made on-the-go for immediate consumption by a sample of British consumers, combined with information on brand level advertising expenditure. In the US the potato chips market was worth $8.8billion in 2012, with 86% of people consuming some potato chips. The UK potato chips market has an annual revenue of more than £2 billion in 2011 with 84% of consumers buying some potato chips.[4]

Our results suggest that advertising is expansionary in the potato chips market, so banning it leads to a reduction in total demand. Advertising also dampens price competition between firms, which means that the fall in demand following an advertising ban is partly mitigated because the ban leads to lower prices which act to increase demand. However the net effect of the ban is to reduce the total quantity of potato chips purchased. Advertising also leads consumers to be less willing to pay for healthier potato chips, so banning it leads them to purchase healthier varieties. The impact on welfare depends crucially on the view that one takes on advertising.

There are several possible effects of advertising on demand - advertising can be *informative*, it can be *persuasive*, and it can be seen as a valuable *characteristic* in its own right. We include advertising in our demand model in a flexible way, which enables us to assess the impact of an advertising ban on demand, and thus on quantities, prices and profits, regardless of which view of advertising is taken. However, the welfare impact of the ban varies depending on the view we take on advertising. If advertising is viewed as a characteristic, then banning it will impact consumer welfare through the removal of this characteristic from the market. Whether this is welfare enhancing or reducing depends on whether the estimates suggest that the characteristic has positive or negative value to consumers. Banning advertising will also impact consumer welfare through its impact on prices. We find that under the characteristic view of advertising, the effect of banning it is to reduce consumer welfare, because consumers attach positive value to advertising and the loss from its removal from the market outweighs the gain associated with firms lowering prices. Conversely, if advertising is viewed as persuasive and distorting consumers from their true preferences, we find that the ban increases consumer welfare, because consumers benefit from no longer making distorted decisions and through lower prices. We can also consider intermediate views where advertising is partial distortionary but is also a valued characteristic.

Our work is related to several literatures. There is a very sizable theoretical and empirical literature on the effects of advertising on demand; Bagwell (2007) provides an excellent survey. Advertising can play

[4]For the size of the US market see http://www.marketresearch.com/MarketLine-v3883/Potato-Chips-United-States-7823721/ ; the size of the UK market see http://www.snacma.org.uk/fact-or-fiction.asp ; and for the number of people who consume potato chips in each country see http://us.kantar.com/business/health/potato-chip-consumption-in-the-us-and-globally-2012/ .

an important role in informing consumers about the quality or characteristics of a product (Stigler (1961) and Nelson (1995)). Most obviously, advertising can be informative about product price, and this can have an important impact on price setting (for instance, see Milyo and Waldfogel (1999) who study the alcohol market). Advertising might also inform consumers about the existence and availability of products (see, inter alia, Sovinsky-Goeree (2008) on personal computers and Ackerberg (2001) and Ackerberg (2003) on distinguishing between advertising that is informative about product existence and prestige advertising in the yoghurt market). Although, as Anderson and Renault (2006) point out, firms may have an incentive to limit the informative content of adverts even when consumers are imperfectly informed (see also Spiegler (2006)).

The early literature on advertising focused on its persuasive nature (Marshall (1921), Braithwaite (1928), Robinson (1933), Kaldor (1950) and Dixit and Norman (1978)), where its purpose is to change consumer tastes. More recently the behavioral economics and neuroeconomics literatures have begun to explore the mechanisms by which advertising affects consumer decision making. Gabaix and Laibson (2006) consider models in which firms might try to shroud negative attributes of their products, while McClure et al. (2004) and Bernheim and Rangel (2004, 2005) consider the ways that advertising might affect the mental processes that consumers use when taking decisions (for example, a shift from the use of deliberative systems to the affective systems that respond more to emotional cues). This literature, in particular Dixit and Norman (1978), Bagwell (2007) and Bernheim and Rangel (2009), raises questions of how welfare should be evaluated, and particularly whether we should use preferences that are influenced by advertising or the "unadvertised self" preferences. Bernheim and Rangel (2009) argue that if persuasive advertising has no information content, then "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." We follow this idea and argue that we can identify and empirically estimate undistorted preferences with our structural demand model, and so can use the model to evaluate changes in welfare from a ban or any regulatory policy that affects those environmental cues.

A third view of advertising is that it enters utility directly (see Becker and Murphy (1993) and Stigler and Becker (1977)). Consumers may like or dislike advertising, and advertising may act as a complement to other goods or characteristics that enter the utility function. The crucial feature that distinguishes this characteristic view of advertising from the persuasive view is how advertising enters into consumer welfare. If advertising is viewed as a characteristic then it does not lead consumers to make decisions that are inconsistent with their true welfare, and consideration of the consumer welfare implications of banning advertising are analogous to those associated with removing or changing any other characteristic.

Our paper also relates to the dynamic games literature in empirical IO. We consider a Markov-Perfect Nash equilibrium (MPNE), as in Maskin and Tirole (1988) and Ericson and Pakes (1995), however for our application we only have to estimate the static first-order conditions, which are sufficient for our counterfactual simulation of an advertising ban. Simulating the effects of an advertising ban on entry and exit decisions would require full estimation of the dynamic game, as in Doraszelski and Markovich (2007) who use the Ericson and Pakes (1995) framework to simulate a game in which single product firms choose advertising, compete in prices and make entry and exit decisions. They show that a ban on advertising can in some circumstances have anticompetitive effects, because firms can use advertising to deter and accommodate entry and induce exit (as in Chamberlin (1933), Dixit (1980), Schmalensee (1983) and Fudenberg and Tirole (1984)).

The literature has largely been interested in addressing the computational burden problem of estimating such dynamic game models (see, inter alia, Rust (1987), Bajari et al. (2007), Ryan (2012) and Fowlie et al. (2013)). Most of this work assumes that the same equilibrium is played in all markets in order to allow consistent estimation of policy functions in all observed markets. A recent advance in Sweeting (2013) circumvents this problem by using parametric approximations to firms' value functions.

While we build a fully dynamic oligopoly model that accounts for the potentially long lasting effects of advertising on firm behavior, we avoid many of the difficult computational problems that arise in such models. In our model firms compete in both prices and advertising; firms strategies in prices and advertising are multidimensional and continuous with a very large set of state variables. If we wanted to estimate the dynamic parameters of the model, we would face a potentially intractable computational problems. However, we are interested in the counterfactual equilibrium in which advertising is banned. We consider a mature market with a stable set of brands and firms, so we can abstract from entry and exit considerations. This simplifies the problem. However, we estimate a model that includes multi-product firms and we do not restrict equilibria to be unique or symmetric or to be constant across markets, but instead we use the fact that advertising state vectors are observed and unique to each equilibrium. In this realistic market setting we consider the impact that an advertising ban will have on price competition.

The rest of the paper is structured as follows. In Section 2 we outline a model of consumer demand that is flexible in the ways that advertising enters, and allows for the possibility that advertising is cooperative so expands the market, or that it is predatory and so potentially contracts the market. We detail how we can evaluate the impact of advertising on consumer welfare under the alternative views that advertising is persuasive and distorts consumers' decisions, that it is a characteristic that consumers value in its own right or an intermediate view that combines these effects. Section 3 presents a dynamic oligopoly model in which multi-product firms compete in price and advertising strategies and discusses how we identify the unobserved marginal costs parameters of the model. Section 3.2 outlines how we conduct the counterfactual simulations. Section 4.1 describes the data used in our application to the UK potato chips market; a unique feature of our data is that we observe purchase decisions for consumption outside the home as well as at home. In this section we also describe the advertising in this market and show that it has little informative content. Section 4.2 describes our estimates and Section 4.3 describes both the pre and post-simulation market equilibria. A final section summarizes and concludes.

2 Demand

We specify a demand model that is flexible in the way that advertising affects both individual and market level demand. We use a random utility discrete choice model in the vein of Berry et al. (1995), Nevo (2001) and Berry et al. (2004). We estimate the model on consumer level data. Berry and Haile (2010, 2014) show that identification of such multinomial choice models requires less restrictive assumptions with micro data (e.g. individual purchase data), compared with when market level data alone is used.

2.1 Consumer Choice Model

Multi-product firms offer brands ($b = 1, ..., B$) in different pack sizes, indexed by s; a product index is defined by a (b, s) pair. Good $(0, 0)$ indexes the outside option of not buying potato chips. We index markets, which are defined as the period of time over which firms take pricing and advertising decisions, by t.

Let i index consumers. We observe individuals on two types of purchase occasion, food on-the-go and food at home, indexed by $\kappa \in \{1, 2\}$. On food on-the-go purchase occasions an individual buys a pack of potato chips for immediate consumption outside of the home; on food at home purchase occasions the main shopper in the household buys potato chips for future consumption at home.

Consumer i purchases the product that provides her with the highest payoff, trading off characteristics that increase her valuation of the product, such as tastiness, against characteristics that decrease her valuation, such as price and possibly 'unhealthiness'. Advertising could affect the weight the consumer places on all of these; it could directly enter as a characteristic that the consumer values, it could change the amount of attention the consumer pays to the other characteristics, or it could change the information the consumer has about the characteristics. In Section 4.1.2 we discuss the nature of advertising in the UK potato chips market; in this market brand advertising has little informational content.

Products have observed and unobserved characteristics. A product's observed characteristics include its price (p_{bst}) and its nutrient characteristic (x_b). The nutrient characteristic might capture both tastiness, if consumers like the taste of salt and saturated fat, and the health consequences of consuming the product, which might reduce the payoff of selecting the product for some consumers. We also assume that there exists a set of advertising states variables, $\mathbf{a_t} = (\mathbf{a_{1t}}, ..., \mathbf{a_{Bt}})$, where $\mathbf{a_{bt}}$ denotes a brand b specific advertising vector of state variables, which may depend on current and past brand advertising, as will be detailed in the Supply Section 3. $\mathbf{z}_{bs}$ denotes functions of the product's pack size, and ξ_{ib} is an unobserved brand characteristic. A consumer's payoff from selecting a product also depends on an i.i.d. shock, ϵ_{ibst}.

Let $\bar{v}_{i\kappa bs}$ denote the consumer's payoff from selecting product (b, s), then the consumer will choose product (b, s) if:

$$\bar{v}_{i\kappa bs}(p_{bst}, \mathbf{a_t}, x_b, \mathbf{z_{bs}}, \xi_b, \epsilon_{ibst}) \geq \bar{v}_{i\kappa bs}(p_{b's't}, \mathbf{a_t}, x_{b'}, \mathbf{z_{b's'}}, \xi_{b'}, \epsilon_{ib's't}) \qquad \forall (b', s') \in \Omega_\kappa,$$

where Ω_κ denotes the set of products available on purchase occasion κ. The i subscript on the payoff function indicates that we will allow coefficients to vary with observed and unobserved (through random coefficients) consumer characteristics. The κ subscript indicates that we allow coefficients to vary between purchases made on-the-go for immediate consumption, and purchases made as part of a main shopping trip for future consumption at home. We allow this variation in order to accommodate the possibility that behavior and preferences might differ when a decision is made for immediate consumption compared to when it is made for delayed consumption. In our application this is important; for example, we find that consumers are more price sensitive when purchasing food on-the-go compared with when they purchase food to be consumed at home. There are potentially many reasons why preference differ between food on-the-go and food at home.

One of our aims in specifying the form of the payoff function is to allow changes in price and advertising to impact demand in a way that is not unduly constrained a priori. We therefore incorporate both observable and unobservable heterogeneity in consumer preferences. Many papers, including Berry et al. (1995), Nevo (2001) and Berry et al. (2004), have illustrated the importance of allowing for unobservable heterogeneity, in particular to allow flexible cross-price substitution patterns. While in differentiated markets it is typically reasonable to impose that goods are substitutes (lowering the price of one good increases demand for a second), it is not reasonable to impose that cross-advertising effects are of a particular sign. A priori we do not know whether more advertising of one brand increases or decreases demand for another brand. Therefore, we include advertising in consumers' payoff function in such a way that allows for the potential for both cooperative or predatory advertising.

We assume that consumer i's payoff from selecting product (b, s) is additive in a term reflecting the effects of price on the payoff function, $\alpha_i(\mathbf{a_{bt}}, p_{bst})$, a term reflecting the net impact of the nutritional content of the product on the payoff function, $\psi_i(\mathbf{a_{bt}}, x_b)$, a term reflecting the direct effects of advertising, $\gamma_i(\mathbf{a_{bt}}, \mathbf{a_{-bt}})$, and a final term capturing other product characteristics, $\eta_i(\mathbf{z}_{bs}, \xi_b)$. We allow all parameters, including the distribution of the random coefficients, to vary for on-the-go and food at home occasions (κ), and by demographic characteristics (income, education, household composition). For notational simplicity we drop the κ subscript on the coefficients - it appears on all coefficients - we retain the i subscript to clarify how we incorporate observed and unobserved heterogeneity. Thus the payoff function is given by:

$$\bar{v}_{ibst} = \alpha_i(\mathbf{a_{bt}}, p_{bst}) + \psi_i(\mathbf{a_{bt}}, x_b) + \gamma_i(\mathbf{a_{bt}}, \mathbf{a_{-bt}}) + \eta_i(\mathbf{z}_{bs}, \xi_b) + \epsilon_{ibst}, \tag{2.1}$$

where we specify the functions:

$$\begin{aligned}
\alpha_i(\mathbf{a_{bt}}, p_{bst}) &= (\alpha_{0i} + \alpha_{1i}\mathbf{a_{bt}})\, p_{bst}, \\
\psi_i(\mathbf{a_{bt}}, x_b) &= (\psi_{0i} + \psi_{1i}\mathbf{a_{bt}})\, x_b, \\
\gamma_i(\mathbf{a_{bt}}, \mathbf{a_{-bt}}) &= \lambda_i \mathbf{a_{bt}} + \rho_i \left(\textstyle\sum_{l \neq b} \mathbf{a_{lt}}\right), \\
\eta_i(\mathbf{z}_{bs}, \xi_b) &= \eta_{1i} z_{bs} + \eta_{2i} z_{bs}^2 + \eta_{3i}\xi_b.
\end{aligned}$$

The coefficients $\pi_i^u = (\alpha_{0i}, \lambda_i, \rho_i, \eta_{3i})$ incorporate observed and unobserved heterogeneity and take the form $\pi_i^u = \pi_0^u + \pi_1^u d_i + \upsilon_i d_i$, where d_i are demographic characteristics and $\upsilon_i \sim N(0, \Sigma_\pi)$; the distribution of these random coefficients is allowed to differ both by demographics and by whether the purchase occasion is for on-the-go or food at home. The coefficients $\pi_i^o = (\alpha_{1i}, \psi_{1i}, \eta_{1i}, \eta_{2i})$ incorporate observed heterogeneity and take the form $\pi_i^o = \pi_0^o + \pi_1^o d_i$.

Advertising enters the payoff function in three distinct ways. We allow advertising to enter directly as a characteristic through $\gamma_i(\mathbf{a_{bt}}, \mathbf{a_{-bt}})$, this can also be viewed as allowing advertising to shift the weight the consumer places on the brand characteristic; the coefficients λ_i and ρ_i can be interpreted as capturing the extent to which time variation in the own brand and competitor advertising state vectors shift the weight consumers place on the brand. We allow advertising to interact with price; the coefficient α_{1i} allows the mean marginal effect of price on the payoff function (within a given demographic group) to shift with advertising (as in Erdem et al. (2008b)). We also allow advertising to interact with the nutrient characteristic; the coefficient ψ_{1i} allows the marginal effect of the nutrient characteristic on the payoff function (within a given demographic group) to shift with advertising. Inclusion of rich heterogeneity in the effects of advertising on the payoff function serves both to capture variation across consumers in responses to advertising (due to both variation in exposure and variation in responsiveness for a given level of exposure) and to allow for rich patterns of demand response to changes in advertising.

In specifying and estimating the demand system we can remain agnostic about whether advertising is informative about product characteristics, persuasive or a characteristic. For instance, it may shift the marginal impact of the nutrient characteristic on the payoff function, because it leads the consumer to be better informed about this characteristic, because it persuades consumers to pay more or less attention to this characteristic than they would in the absence of advertising, or because it is a product characteristic that enters interactively with the nutrient characteristic. It is when we use the model to make welfare statements that we need to take a view of the role of advertising.

Without further restrictions, we cannot separately identify the baseline nutrient characteristic coefficient ψ_{0i} from the unobserved brand effect $(\eta_{3i}\xi_b)$, although we can identify a linear combination of the two effects: $\zeta_{ib} = \psi_{0i}x_b + \eta_{3i}\xi_b$. We do not need to separately estimate these coefficients for our counterfactual simulations. However, we can recover the baseline effect of the nutrient characteristic on consumer tastes under the additional assumption that the nutrient characteristic is mean independent from the unobserved brand characteristic, using an auxiliary minimum distance estimation between a set of estimated brand effects ζ_{ib} and the nutrient characteristic x_b.

We allow for the possibility that the consumer chooses not to purchase potato chips; the payoff from selecting the outside option takes the form:

$$\bar{v}_{i00t} = \zeta_{i0} + \epsilon_{i00t}.$$

Assuming ϵ_{ibst} is i.i.d. and drawn from a type I extreme value distribution, the probability that consumer i buys product (b, s) in period (market) t is:

$$s_{ibs}(\mathbf{a_t}, \mathbf{p_t}) = \frac{\exp[\alpha_i\left(\mathbf{a_{bt}}, p_{bst}\right) + \psi_i\left(\mathbf{a_{bt}}, x_b\right) + \gamma_i(\mathbf{a_{bt}}, \mathbf{a_{-bt}}) + \eta_i(\mathbf{z_{bs}}, \xi_b)]}{\sum_{(b',s')\in\Omega_\kappa} \exp\left[\alpha_i\left(\mathbf{a_{b't}}, p_{b's't}\right) + \psi_i\left(\mathbf{a_{b't}}, x_{b'}\right) + \gamma_i(\mathbf{a_{b't}}, \mathbf{a_{-b't}}) + \eta_i(\mathbf{z_{b's'}}, \xi_{b'})\right]}. \tag{2.2}$$

2.1.1 Consumer Willingness to Pay for the Nutrient Characteristic

It is interesting to consider how the willingness to pay for a change in the nutrient characteristic changes with the own-brand advertising state variables $\mathbf{a_{bt}}$. We define the nutrient characteristic x_b such that a higher value corresponds to lower nutritional quality and we consider a change in x_b that *reduces* product unhealthiness, so the willingness to pay for a healthier product is:

$$WTP_{ibt} = \frac{\partial\bar{v}_{ibst}/\partial x_b}{\partial\bar{v}_{ibst}/\partial p_{bst}} = \frac{\psi_{0i} + \psi_{1i}\mathbf{a_{bt}}}{\alpha_{0i} + \alpha_{1i}\mathbf{a_{bt}}}. \tag{2.3}$$

Advertising state variables affect the willingness to pay of each consumer. If consumers positively value income and product healthiness then the marginal effect of price and the nutrient characteristic in the payoff function will be negative ($\alpha_{0i} + \alpha_{1i}\mathbf{a_{bt}} < 0$ and $\psi_{0i} + \psi_{1i}\mathbf{a_{bt}} < 0$), and the willingness to pay for a healthier product (a decrease in the nutrient characteristic) will be positive. However, whether the willingness to pay for healthiness will decrease with advertising will depend on the relative signs and magnitudes of the interactions between advertising and price and the nutrient characteristic.

2.1.2 Price and Advertising Effects

The specification of the payoff function described in the previous section responds to both the need for flexibility and the need for parsimony. We allow for the possibility that an increase in the advertising state variable for one brand, b, increases demand for another brand b', in which case the advertising is cooperative with respect to brand b'. We also allow for the alternative possibility that it decreases demand for brand b', in which case the advertising is predatory with respect to brand b'. The size of the total market can expand or contract in response to an increase in the brand b advertising state. It is important that we include advertising in the model flexibly enough to allow for the possibility of these different effects.

With our specification of the consumer choice model the marginal impact of a change in an advertising state variable of one brand ($b > 0$) on the individual level choice probabilities is given by:

$$\begin{aligned}
\frac{\partial s_{ibst}}{\partial a_{bt}} =& s_{ibst}\left[\tilde{\lambda}_{ibst} - \rho_i(1 - s_{i00t}) - \sum\nolimits_{s' \in K_b}(\tilde{\lambda}_{ibs't} - \rho_i)s_{ibs't}\right] \\
\frac{\partial s_{ib'st}}{\partial a_{bt}} =& s_{ib'st}\left[\rho_i s_{i00t} - \sum\nolimits_{s' \in K_b}(\tilde{\lambda}_{ibs't} - \rho_i)s_{ibs't}\right] \qquad \text{for } b' \neq (0, b) \\
\frac{\partial s_{i00t}}{\partial a_{bt}} =& - s_{i00t}\left[\rho_i(1 - s_{i00t}) + \sum\nolimits_{s' \in K_b}(\tilde{\lambda}_{ibs't} - \rho_i)s_{ibs't}\right],
\end{aligned}$$

where $\tilde{\lambda}_{ibst} = \lambda_i + \alpha_{1i}p_{bst} + \psi_{1i}x_b$ and K_b denotes the set of all pack sizes s that brand b is available in.

The interaction of the advertising state variable a_{bt} with price and the nutrient characteristic, and the possibility that competitor advertising directly enters the payoff function are important in allowing for a flexible specification. If we do not allow competitor advertising to affect demand (imposing $\rho_i = 0$), and do not allow advertising to affect the consumer's responsiveness to price or nutrients (imposing $\alpha_{1i} = 0$ and $\psi_{1i} = 0$), then we directly rule out cooperative advertising and market contraction. In this case, the marginal impacts would be, for $b > 0$:

$$
\begin{aligned}
\frac{\partial s_{ibst}}{\partial a_{bt}} &= \lambda_i s_{ibst} \left[1 - \sum\nolimits_{s' \in K_b} s_{ibs't}\right] \\
\frac{\partial s_{ib'st}}{\partial a_{bt}} &= -\lambda_i s_{ib'st} \left[\sum\nolimits_{s' \in K_b} s_{ibs't}\right] \qquad \text{for } b' \neq b.
\end{aligned}
$$

In this restricted model, in order for advertising to have a positive own effect (so $\partial s_{ibst}/\partial a_{bt} > 0$) we require $\lambda_i > 0$. In this case, advertising is predatory (since $\partial s_{ib'st}/\partial a_{bt} < 0$), and it necessarily leads to market expansion (since $\partial s_{i00t}/\partial a_{bt} < 0$).

Allowing α_{1i} to be non-zero, but with no competitor advertising effect ($\rho_i = 0$), makes the model more flexible. However, it will in general also restrict advertising to be predatory, and to lead to market expansion if own advertising increases own market share ($\partial s_{ibst}/\partial a_{bt} > 0$). But by allowing $\rho_i \neq 0$ we can capture more general effects. This does come at the expense of making direct interpretation of the advertising coefficients more difficult, for example, we can have $\lambda_i < 0$ but nonetheless have advertising have a positive own demand effect. However, it is straightforward to use estimates of the demand model to shut off advertising of one brand, to determine the effect it has on demands.

The interaction of advertising with price also allows advertising to have a direct impact on consumer level price elasticities. In particular, the specification (2.1) yields consumer level price elasticities given by, for $b > 0$ and $s > 0$:

$$
\begin{aligned}
\frac{\partial \ln s_{ibst}}{\partial \ln p_{bst}} &= (\alpha_{0i} + \alpha_{1i} a_{bt})(1 - s_{ibst}) p_{bst} \\
\frac{\partial \ln s_{ib's't}}{\partial \ln p_{bst}} &= -(\alpha_{0i} + \alpha_{1i} a_{bt}) s_{ibst} p_{bst} \qquad \text{for } b' \neq b \text{ or } s' \neq s.
\end{aligned}
$$

Hence, advertising impacts consumer level price elasticities in a flexible way, through its impact on choice probabilities and through its impact on the marginal effect of price on the payoff function captured by α_{1i}.

2.2 Consumer Welfare

We have argued that the demand model presented above is sufficiently flexible to capture the impact of pricing and advertising on demand regardless of which view (informative about product characteristics, persuasive or a characteristic) we take about advertising. However, we are ultimately interested in how a ban on advertising will affect welfare, which includes consumer welfare, profits of firms that manufacture and sell potato chips and potentially also firms in the advertising industry.[5] Making statements about consumer welfare requires that we take a stance on which view of advertising is most appropriate.

In Section 4.1.2 we argue that advertising in the UK potato chips market has little informational content. This is true of much advertising in consumer goods markets, and particularly in junk food markets. We therefore focus our discussion of consumer welfare on the difference between advertising being a characteristic of the product that consumers value (Stigler and Becker (1977) and Becker and Murphy (1993)) or advertising being persuasive (Robinson (1933), Kaldor (1950)) and potentially distorting consumer decision making. Under the first of these two views, consumer welfare considerations are relatively straightforward. Under the second view it is less clear how to value consumers' choices. Dixit and Norman (1978) study the welfare effects of advertising and find that the conditions under which welfare increases or decreases depends on whether one uses pre or post advertising tastes to evaluate welfare. More recently, Bernheim and Rangel (2005) suggests that advertising might lead consumers to act as non-standard decision makers; advertising providing environmental "cues" to consumers. While policies that improve cognitive processes are potentially welfare enhancing, for example, if the environmental cues have information content, persuasive advertising also might distort choices in ways that do not enhance welfare, and Bernheim and Rangel (2009) say, *"choices made in the presence of those cues are therefore predicated on improperly processed information, and welfare evaluations should be guided by choices made under other conditions."*

We focus on welfare measures of the direct monetary costs to consumers and firms of an advertising ban. In the empirical application we also report the change in the nutrient characteristic of products purchased; these could be combined with estimates from the medical literature on the health implications of consumption of those nutrients (salt and saturated fat being among the most important ones) to say something about the long term health effects.

2.2.1 Advertising as a characteristic

If we consider the payoff function specified by equation (2.1) to also represent the consumer's indirect utility function, as would be the case if we view advertising as a characteristic, then the expected utility for consumer i given pre-ban levels of advertising and prices $(\mathbf{a_t}, \mathbf{p}_t)$, denoted $W_i(\mathbf{a_t}, \mathbf{p}_t)$, is:

$$W_i(\mathbf{a_t}, \mathbf{p_t}) = E\left[\max_{(b,s)\in\Omega_\kappa} \bar{v}_{ibst}\right], \tag{2.4}$$

[5] Though we have less to say about this, we can state the total advertising budgets, which represent an upper bound on advertisers' profits.

where $\bar{v}_{ibst}$ is as in equation (2.1):

$$\bar{v}_{ibst} = \alpha_i\left(\mathbf{a_{bt}}, p_{bst}\right) + \psi_i\left(\mathbf{a_{bt}}, x_b\right) + \gamma_i(\mathbf{a_{bt}}, \mathbf{a_{-bt}}) + \eta_i(\mathbf{z_{bs}}, \xi_b) + \epsilon_{ibst},$$

and where maximization is over all products in the choice set Ω_κ, including the outside option. In this case, and given that the error term is distributed type I extreme value, expected consumer welfare (conditional on values of the random coefficients) takes the standard closed form (Small and Rosen (1981)), up to the additive Euler constant:

$$W_i\left(\mathbf{a_t}, \mathbf{p_t}\right) = \ln\left[\sum_{(b,s)\in\Omega_\kappa} \exp\left[\alpha_i\left(\mathbf{a_{bt}}, p_{bst}\right) + \psi_i\left(\mathbf{a_{bt}}, x_b\right) + \gamma_i(\mathbf{a_{bt}}, \mathbf{a_{-bt}}) + \eta_i(\mathbf{z_{bs}}, \xi_b)\right]\right]. \tag{2.5}$$

Consider a counterfactual equilibrium in which there is no advertising. We define the nature of this equilibrium more precisely in Section 3.2, but for now denote the equilibrium by $(\mathbf{0}, \mathbf{p}^0)$. The change in the expected utility of consumer i from banning firms from advertising is:

$$\begin{aligned} W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - W_i\left(\mathbf{a_t}, \mathbf{p_t}\right) &= W_i\left(\mathbf{0}, \mathbf{p_t}\right) - W_i\left(\mathbf{a_t}, \mathbf{p_t}\right) \quad \text{(characteristic effect)} \\ &+ W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - W_i\left(\mathbf{0}, \mathbf{p_t}\right) \quad \text{(price competition effect).} \end{aligned} \tag{2.6}$$

Under this view banning advertising has two distinct effects on consumer welfare. The advertising provides the consumer with a characteristic (the advertising itself) which the consumer will place some value on (positive or negative). Banning it removes this characteristic; we label this effect the "characteristic effect". Banning advertising also has an impact on the equilibrium prices in the market, which in turns affects consumer welfare. We label this second channel as the "price competition effect". This effect will be present whatever welfare perspective we adopt.

2.2.2 Advertising as distorting choices

An alternative view is that advertising distorts consumer decision making. If advertising is persuasive, then a social planner might consider that consumers' preferences in the absence of advertising provides a better reflection of their true utility. For example, the "advertised self" might behave with a shorter time horizon, while the "unadvertised self" might take a longer perspective (Bernheim and Rangel (2005)).

Under this view of advertising, decisions made when advertising is non-zero maximize a payoff function that does not coincide with the consumer's utility function. Consumers will choose the product that provides them with the highest payoff $\bar{v}_{ibst}$, but the true underlying utility is based on the consumer's product valuation in the absence of advertising:

$$\widehat{v}_{ibst} = \alpha_i\left(\mathbf{0}, p_{bst}\right) + \psi_i\left(\mathbf{0}, x_b\right) + \gamma_i(\mathbf{0},\mathbf{0}) + \eta_i(\mathbf{z_{bs}}, \xi_b) + \epsilon_{ibst}. \tag{2.7}$$

In this case the consumer's expected utility at advertising state and price vectors $(\mathbf{a_t}, \mathbf{p}_t)$ is given by evaluating the choice made by maximizing the payoff function (equation (2.1)) at preferences described by equation (2.7):

$$\widehat{W}_i\left(\mathbf{a_t}, \mathbf{p_t}\right) = E\left[\widehat{v}_{\underset{(b,s)\in\Omega_\kappa}{\arg\max}\{\bar{v}_{ibst}\}}\right]. \tag{2.8}$$

Noting that

$$\widehat{v}_{ibst} = \bar{v}_{ibst} - \alpha_i\left(\mathbf{a_{bt}}, p_{bt}\right) + \alpha_i\left(\mathbf{0}, p_{bt}\right) - \psi_i\left(\mathbf{a_{bt}}, x_b\right) + \psi_i\left(\mathbf{0}, x_b\right) - \gamma_i(\mathbf{a_{bt}}, \mathbf{a_{-bt}}) + \gamma_i(\mathbf{0},\mathbf{0}), \tag{2.9}$$

and defining $(b^*, s^*) = \underset{(b,s)\in\Omega_\kappa}{\arg\max}\{\bar{v}_{ibst}\}$, we can write $\widehat{W}_i\left(\mathbf{a_t}, \mathbf{p}_t\right)$ as:

$$\begin{aligned}\widehat{W}_i(\mathbf{a_t}, \mathbf{p_t}) &= E[\bar{v}_{ib^*s^*t}] - E[\alpha_i\left(\mathbf{a_{b^*t}}, p_{b^*t}\right) - \alpha_i\left(\mathbf{0}, p_{b^*t}\right) + \psi_i\left(\mathbf{a_{b^*t}}, x_{b^*}\right) - \psi_i\left(\mathbf{0}, x_{b^*}\right) + \gamma_i(\mathbf{a_{bt}}, \mathbf{a_{-bt}}) - \gamma_i(\mathbf{0},\mathbf{0})] \\ &= W_i(\mathbf{a_t}, \mathbf{p_t}) \\ &- \sum_{(b,s)\in\Omega_\kappa} s_{ibst}\left[(\alpha_i(\mathbf{a_{bt}}, p_{bst}) - \alpha_i(\mathbf{0}, p_{bst})) + (\psi_i(\mathbf{a_{bt}}, x_b) - \psi_i(\mathbf{0}, x_b)) + (\gamma_i(\mathbf{a_{bt}}, \mathbf{a_{-bt}}) - \gamma_i(\mathbf{0},\mathbf{0}))\right],\end{aligned} \tag{2.10}$$

where s_{ibst} is given by equation (2.2). This says that when choices are distorted by advertising, expected utility is equal to expected utility if advertising was in the consumer's utility function, minus a term which measures the welfare cost to the consumer of making choices that do not maximize her true underlying utility function.

When advertising is viewed as distorting decision making, the impact of banning advertising should be evaluated under the welfare standard of $\widehat{v}_{ibst}$, and the consumer welfare difference between the post and pre advertising ban equilibria is:

$$\begin{aligned} W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - \widehat{W}_i\left(\mathbf{a_t}, \mathbf{p_t}\right) &= W_i\left(\mathbf{0}, \mathbf{p_t}\right) - \widehat{W}_i\left(\mathbf{a_t}, \mathbf{p_t}\right) \quad \text{(choice distortion effect)} \\ &+ W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - W_i\left(\mathbf{0}, \mathbf{p_t}\right) \quad \text{(price competition effect)} \end{aligned} \tag{2.11}$$

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

In this case advertising has the effect of inducing the consumer to make suboptimal choices. Banning advertising removes this distortion to decision making, which benefits consumers. We label this the "choice distortion effect". As before, banning advertising also affects consumer welfare through the "price competition effect" channel.

2.2.3 Advertising as partially valuable and partially distortionary

The two welfare perspectives outlined above can, in some sense, be thought of as the extremes: either all of the effect of advertising enters into the consumer's true underlying utility, or all of the effect of advertising is to distort choices, and no advertising enters into utility. In some cases though, it may be that advertising has a dual role, being in part a valuable characteristic and in part acting to distort decisions. It is possible to account for this dual role of advertising on welfare.

To illustrate, suppose advertising increases the consumer's true valuation of the brand characteristic, but it also plays a distortionary role with respect to the weight she places on the product's price and nutrient characteristic. In this case the underlying utility from product (b, s) is:

$$\widetilde{v}_{ibst} = \alpha_i\left(\mathbf{0}, p_{bst}\right) + \psi_i\left(\mathbf{0}, x_b\right) + \gamma_i(\mathbf{a_{bt}}, \mathbf{a_{-bt}}) + \eta_i(\mathbf{z_{bs}}, \xi_b) + \epsilon_{ibst}. \tag{2.12}$$

Since the consumer makes distorted decisions, maximizing the payoff function $\bar{v}_{ibst}$, the expected welfare at pre ban advertising state and price vectors $(\mathbf{a_t}, \mathbf{p}_t)$ is given by:

$$\begin{aligned}\widetilde{W}_i\left(\mathbf{a_t}, \mathbf{p_t}\right) =& E\left[\widetilde{v}_{\arg\max_{(b,s)\in\Omega_\kappa}\{\bar{v}_{ibst}\}}\right] \\ =& W_i\left(\mathbf{a_t}, \mathbf{p_t}\right) - \sum_{(b,s)\in\Omega_\kappa} s_{ibst}\left[\left(\alpha_i\left(\mathbf{a_{bt}}, p_{bst}\right) - \alpha_i\left(\mathbf{0}, p_{bst}\right)\right) + \left(\psi_i\left(\mathbf{a_{bt}}, x_b\right) - \psi_i\left(\mathbf{0}, x_b\right)\right)\right].\end{aligned} \tag{2.13}$$

Under this third view of welfare, when thinking about the various channels through which advertising affects consumer welfare, it is useful to define what consumer welfare would be if advertising only affected demand through entering as a characteristic (and so consumer's made optimal decisions under non-zero advertising). This is given by:

$$\widetilde{\widetilde{W}}_i\left(\mathbf{a_t}, \mathbf{p_t}\right) = E\left[\max_{(b,s)\in\Omega_\kappa} \widetilde{v}_{ibst}\right]. \tag{2.14}$$

We can then write the consumer welfare difference between the post and pre advertising ban situations, under the welfare standard of $\widetilde{v}_{ibst}$, as:

$$
\begin{aligned}
W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - \widetilde{W}_i\left(\mathbf{a_t}, \mathbf{p_t}\right) &= \widetilde{\widetilde{W}}_i\left(\mathbf{a_t}, \mathbf{p_t}\right) - \widetilde{W}_i\left(\mathbf{a_t}, \mathbf{p_t}\right) \quad \text{(choice distortion effect)} \\
&+ W_i\left(\mathbf{0}, \mathbf{p_t}\right) - \widetilde{\widetilde{W}}\left(\mathbf{a_t}, \mathbf{p_t}\right) \quad \text{(characteristic effect)} \\
&+ W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - W_i\left(\mathbf{0}, \mathbf{p_t}\right) \quad \text{(price competition effect)}
\end{aligned} \tag{2.15}
$$

where we use the fact that $\widetilde{W}_i\left(\mathbf{0}, \mathbf{p}\right) = W_i\left(\mathbf{0}, \mathbf{p}\right)$.

In this case the total welfare impact of an advertising ban can be decomposed into three terms. Banning advertising removes the distortionary role advertising plays with respect to the weight the consumer places on price and the nutrient characteristic. Banning it therefore benefits consumers through the "choice distortion effect". But removing advertising also eliminates the role it plays in contributing to utility through adding to the consumer's true valuation of the brand characteristic - the "characteristic effect". And finally banning advertising impacts consumer welfare through its impact on equilibrium prices - the "price competition effect".

2.2.4 Compensating Variation

To compute monetary values that allow us to aggregate changes in consumer welfare with changes in firm variable profits we can define corresponding compensating variations as:

$$
CV_i\left(\mathbf{a_t}, \mathbf{p_t}, \mathbf{p_t^0}\right) = \frac{1}{\alpha_{0i}}\left[W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - W_i\left(\mathbf{a_t}, \mathbf{p_t}\right)\right], \tag{2.16}
$$

$$
\widehat{CV}_i\left(\mathbf{a_t}, \mathbf{p_t}, \mathbf{p_t^0}\right) = \frac{1}{\alpha_{0i}}\left[W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - \widehat{W}_i\left(\mathbf{a_t}, \mathbf{p_t}\right)\right], \tag{2.17}
$$

$$
\widetilde{CV}_i\left(\mathbf{a_t}, \mathbf{p_t}, \mathbf{p_t^0}\right) = \frac{1}{\alpha_{0i}}\left[W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - \widetilde{W}_i\left(\mathbf{a_t}, \mathbf{p_t}\right)\right], \tag{2.18}
$$

where α_{0i} is the (post ban) marginal utility of income.

2.3 Market Demand and Consumer Welfare

We can obtain market level demand and aggregate welfare once we know individual demand. The inclusion of rich observed and unobserved consumer heterogeneity means that flexibility in individual demand will translate into even more flexibility in market level demand. We consider firms to take pricing and advertising decisions each month t. We measure the potential size of the potato chips market (or maximum number of potato chips that could be purchased) as being equal to the number of shopping occasions on which snacks were purchased, denote this M_t. This definition of the market size implies that we assume that changes in pricing or advertising in the potato chips market may change consumers' propensity to buy potato chips, but not their propensity to go shopping to buy a snack product. We model the share of the potential market accounted for by purchases of product (b, s), by averaging over the individual purchase probabilities given by equation (2.2).

In order to aggregate individual choice probabilities over individual purchase occasions into market shares we use the following assumption:

Assumption 1: Random coefficients $\pi_i^u = (\alpha_{0i}, \lambda_i, \rho_i, \eta_{3i})$ are i.i.d. across consumers, within purchase occasion type.

As seen in Section 2.1, we allow the mean and variance of the random coefficient to vary with observed household characteristics, d_i. We integrate over consumers' observed and unobserved preferences; under assumption 1 the share of the potential market accounted for by product (b, s) is given by:

$$s_{bs}(\mathbf{a_t}, \mathbf{p_t}) = \int s_{ibs}(\mathbf{a_t}, \mathbf{p_t}) dF(\pi_i^u, \pi_i^o | d_i). \tag{2.19}$$

Assumption 1 guarantees that the market share function $s_{bs}(.,.)$ is not time dependent. A generalization where the distribution of observed preference shifters d_i changes over time in a Markov way is straightforward and would simply mean that the parameters of this distribution at time t would be an additional argument of this function $s_{bs}(.,.)$.

Similarly, we can compute market level compensating variations using:

$$CV\left(\mathbf{a_t}, \mathbf{p_t}, \mathbf{p_t^0}\right) = \int CV_i\left(\mathbf{a_t}, \mathbf{p_t}, \mathbf{p_t^0}\right) dF(\pi_i^u, \pi_i^o | d_i), \tag{2.20}$$

$$\widehat{CV}\left(\mathbf{a_t}, \mathbf{p_t}, \mathbf{p_t^0}\right) = \int \widehat{CV}_i\left(\mathbf{a_t}, \mathbf{p_t}, \mathbf{p_t^0}\right) dF(\pi_i^u, \pi_i^o | d_i), \tag{2.21}$$

$$\widetilde{CV}\left(\mathbf{a_t}, \mathbf{p_t}, \mathbf{p_t^0}\right) = \int \widetilde{CV}_i\left(\mathbf{a_t}, \mathbf{p_t}, \mathbf{p_t^0}\right) dF(\pi_i^u, \pi_i^o | d_i). \tag{2.22}$$

2.4 Identification

A common concern in empirical demand analysis is whether the ceteris paribus impact of price on demand is identified. In the industrial organization literature the most common concern is that price is correlated with an unobserved product effect (either some innate unobserved characteristic of the product or some market specific shock to demand for the product); failure to control for the unobserved product effect will mean that we can not identify the true effect of price on demand. Following the seminal contribution of Berry (1994) and Berry et al. (1995), the literature estimating differentiated product demand with market level data has dealt with the endogeneity concern by controlling for market varying product effects, using an auxiliary IV regression to obtain consistent estimates of the price coefficient. Our strategy for identifying the price effect differs from the typical "BLP" approach, and instead exploits the richness of our micro data, and the fact that the UK retail food market is characterized by close to national pricing.[6]

The use of individual transaction level data, coupled with the lack of geographic variation in pricing, means in our context that concerns over the endogeneity of price translates into whether differences in price either across products or through time are correlated with the *individual level* errors (ϵ_{ibst}), conditional on all other characteristics included in the model. A typical concern is that marketing activities are correlated with prices, but we observe and control for all relevant advertising in the market. Hence, we are able to exploit time series variation in price, after controlling for firms' advertising activities. A second common issue is that some unobserved characteristic of products is not adequately captured by the model and firms, which set prices based in part on the demand they face, will set prices that are correlated with the unobserved characteristic. A strength of our data is that we observe barcode level transactions, and we are therefore able to model demand for products that are defined more finely than brands (in particular each brand is available in a variety of pack sizes). We control for both brand effects, which capture unobserved characteristics of brand, as well as pack size. So a second source of price variation we exploit is differences across brand in how unit price varies across pack size (non-linear pricing). Taken together we believe that national pricing, consumer level demand, and the inclusion of advertising and brand effects alleviate much of the typical endogeneity worries.

A related issue is whether we are able to identify the ceteris paribus effect of advertising on demand. Like pricing decisions, in the UK advertising decisions are predominantly taken at the national level. The majority of advertising is done on national television, meaning that all households are subject to the same vector of advertising. This implies that the cross sectional variation of individual taste shocks is not correlated with advertising since it is common to all consumers, which highlights the advantage of consumer level data. We assume that individual errors in our demand model are not correlated with national brand advertising. In our counterfactual we use the model to predict demand in the absence of advertising. One potential concern is whether we are predicting advertising levels outside the range of variation we observe in the data, which could lead to a concern that we are not able to identify behavior in the absence of advertising. Fortunately, as we make clear in Section 4.1.2, for a number of the brands in the market, we observe the advertising state variable at (very close to) zero.

[6]In the UK most supermarkets implement a national pricing policy following the Competition Commission's investigation into supermarket behavior (Competition Commission (2000)).

3 Supply

We consider a dynamic oligopoly game where both price and advertising are strategic variables. The market structure is assumed to be fixed both in terms of the firms in the market, indexed $j = 1, .., J$, and in terms of the products produced by each firm. Let F_j denote the set of products produced by firm j (a product is defined by its brand b and size s), and B_j denote the set of brands owned by firm j. We abstract from entry and exit considerations.

3.1 Oligopoly Competition in Prices and Advertising

Before describing the details of the dynamic oligopoly game, we start by writing the objective function of firms as a function of strategic variables, prices and advertising expenditures, and the vectors of state variables. Let c_{bst} denote the marginal cost of product (b, s) at time t. The firm owning product (b, s) chooses the product's price, p_{bst}, and advertising expenditures, e_{bt}, for the brand b in each period t. The intertemporal variable profit of firm j at period 0 is:

$$\sum\nolimits_{t=0}^{\infty} \beta^t \left[\sum\nolimits_{(b,s)\in F_j} (p_{bst} - c_{bst})\, s_{bs} (\mathbf{a_t}, \mathbf{p_t})\, M_t - \sum\nolimits_{b \in B_j} e_{bt} \right], \tag{3.1}$$

where the time t advertising state vector $\mathbf{a_t}$ depends on the vector of current brand advertising expenditures $\mathbf{e_t} = (e_{1t}, ..., e_{Bt})$ and possibly on all past advertising expenditures such that

$$\mathbf{a_t} = \mathcal{A} (\mathbf{e_t}, \mathbf{e_{t-1}}, .., \mathbf{e_{-\infty}}).$$

In order for the game to have an equilibrium we must impose restrictions on the functional $\mathcal{A} (., ..., .)$ for the state space to remain of finite dimension.

As in Erdem et al. (2008a), we assume that the dynamic effect of advertising on demand is such that the state advertising variables are equal to a geometric sum of current and past advertising expenditure:

$$\mathcal{A} (\mathbf{e_t}, \mathbf{e_{t-1}}, .., \mathbf{e_{-\infty}}) = \sum\nolimits_{n=0}^{+\infty} \delta^n \mathbf{e_{t-n}},$$

which means that the dimension of the state space remains finite, since $\mathbf{a_t} = \mathcal{A} (\mathbf{a_{t-1}}, \mathbf{e_t}) = \delta \mathbf{a_{t-1}} + \mathbf{e_t}$. a_{bt} is akin to a stock of advertising goodwill that decays over time at rate δ, but that can be increased with expenditure e_{bt}. An alternative would be to specify that the state vector $\mathbf{a_t}$ depends on the vector of current brand advertising expenditures $\mathbf{e_t} = (e_{1t}, .., e_{Bt})$ and a maximum of L lagged advertising expenditures such that

$$\mathbf{a_t} = \mathcal{A}\left(\mathbf{e_t}, \mathbf{e_{t-1}}, .., \mathbf{e_{t-L}}\right).$$

In this case, the advertising state vector at the beginning of period t is not $\mathbf{a_{t-1}}$ but is $(\mathbf{e_{t-1}}, .., \mathbf{e_{t-L}})$. All of the following discussion can accommodate this case.

We assume that at each period t all firms observe the total market size M_t and the vector of all firms' marginal costs $\mathbf{c_t}$. We denote the information set $\theta_t = (M_t, \mathbf{c_t})$. We assume that firms form symmetric expectations about future shocks according to the following assumption:

Assumption 2: Marginal costs and market size follow independent Markov processes such that for all t, $E_t\left[c_{bst+1}\right] = c_{bst}$ and $E_t\left[M_{t+1}\right] = M_t$.

We follow the majority of the empirical literature by restricting our attention to pure Markov strategies (see, inter alia, Ryan (2012), Sweeting (2013) and Dubé et al. (2005)). This restrict firms' strategies to depend only on payoff relevant state variables, $(\mathbf{a_{t-1}}, \theta_t)$. For each firm j, a Markov strategy σ_j is a mapping between the state variables $(\mathbf{a_{t-1}}, \theta_t)$, and the firm j decisions $\{p_{bst}\}_{(b,s)\in F_j}, \{e_{bt}\}_{b\in B_j}$, which consist of choosing prices and advertising expenditures for the firm's own products and brands ($\sigma_j\left(\mathbf{a_{t-1}}, \theta_t\right) = (\{p_{bst}\}_{(b,s)\in F_j}, \{e_{bt}\}_{b\in B_j})$).

There is no guarantee that a Markov Perfect Equilibrium (MPE) in pure strategies of this dynamic game exists, or, if it does exist, that it is unique. In a discrete version of this game, existence of a symmetric MPE in pure strategies follows from the arguments in Doraszelski and Satterthwaite (2003, 2010), provided that we impose an upper bound on advertising strategies. Ericson and Pakes (1995) and Doraszelski and Satterthwaite (2003) provide general conditions for the existence of equilibria in similar games, but as our model set up differs the conditions cannot be directly applied in our case. Therefore we assume the technical conditions for the existence of a subgame perfect Markov equilibrium of this game are satisfied, and below we use necessary conditions to characterize an equilibrium (Maskin and Tirole (2001)). We also do not need to assume that an equilibrium is unique, and indeed it is perfectly possible that this game has multiple equilibria. We now turn to characterize the equilibria of this game.

We first show that the firm's intertemporal profit maximization can be restated using a recursive formulation. In this dynamic oligopoly game, each firm j makes an assumption on the competitor's strategy profiles denoted σ_{-j}, where $\sigma_{-j}\left(\mathbf{a_{t-1}}, \theta_t\right) = \left(\sigma_1\left(\mathbf{a_{t-1}}, \theta_t\right), .., \sigma_{j-1}\left(\mathbf{a_{t-1}}, \theta_t\right), \sigma_{j+1}\left(\mathbf{a_{t-1}}, \theta_t\right), .., \sigma_J\left(\mathbf{a_{t-1}}, \theta_t\right)\right)$. Equilibrium decisions are generated by a value function, $\pi_j^*(.,.)$, that satisfies the following Bellman equation

$$\pi_j^*\left(\mathbf{a_{t-1}}, \theta_t\right) = \max_{\{p_{bst}\}_{(b,s)\in F_j}, \{e_{bt}\}_{b\in B_j}} \sum_{(b,s)\in F_j} \left(p_{bst} - c_{bst}\right) s_{bs}\left(\mathbf{a_t}, \mathbf{p_t}\right) M_t - \sum_{b\in B_j} e_{bt} + \beta E_t\left[\pi_j^*\left(\mathbf{a_t}, \theta_{t+1}\right)\right],$$

where

$$\mathbf{a_t} = (a_{1t}, .., a_{Bt}) = (\mathcal{A}(a_{1t-1}, e_{1t}), .., \mathcal{A}(a_{Bt-1}, e_{Bt})).$$

The Bellman equation is thus conditional on a specific competitive strategy profile σ_{-j}. A MPE is then a list of strategies, σ_j^* for $j = 1, .., J$, such that no firm deviates from the action prescribed by σ_j^* in any subgame that starts at some state $(\mathbf{a_{t-1}}, \theta_t)$.

We show in a Web Appendix that, for a given continuous Markov competitor strategy profile σ_{-j} (which could be the one obtained in one of the many possible MPE), and under additional technical assumptions on the sufficiency of first-order conditions for price and advertising strategies, this recursive equation for firm j has a solution using standard dynamic programming tools (Stokey et al. (1989)). With other players' price and advertising strategies fixed, one just needs to check technical conditions for this recursive equation to define a contraction mapping to guarantee existence of a fixed point. Then, a solution of the Bellman equation π_j^* will correspond to each MPE of the dynamic game.

Consequently, the maximization problem of the firm at time t is equivalent to the following program:

$$\max_{\{p_{bst}\}_{(b,s)\in F_j}, \{e_{bt}\}_{b\in B_j}} \quad \Pi_j(\mathbf{p_t}, \mathbf{e_t}, \mathbf{a_{t-1}}, \theta_t) \equiv \sum_{(b,s)\in F_j} (p_{bst} - c_{bst}) s_{bs}(\mathbf{a_t}, \mathbf{p_t}) M_t - \sum_{b\in B_j} e_{bt} + \beta E\left[\pi_j^*(\mathbf{a_t}, \theta_{t+1})\right],$$

where $\pi_j^*(\mathbf{a_t}, \theta_{t+1})$ is the next period discounted profit of firm j, given the vector of future advertising states $\mathbf{a_t} = (a_{1t}, .., a_{Bt})$. This profit is the one obtained by the firm choosing optimal prices and advertising expenditures in the future given all state variables.

Assuming that the technical conditions for the profit function to be differentiable in price and have a single maximum hold we can use the first-order conditions of firm j profit with respect to prices for each $(b, s) \in F_j$:

$$\frac{\partial \Pi_j}{\partial p_{bst}}(\mathbf{p_t}, \mathbf{e_t}, \mathbf{a_{t-1}}, \theta_t) = s_{bs}(\mathbf{a_t}, \mathbf{p_t}) + \sum_{(b',s')\in F_j} (p_{b's't} - c_{b's't}) \frac{\partial s_{b's'}(\mathbf{a_t}, \mathbf{p_t})}{\partial p_{bst}} = 0. \tag{3.2}$$

We can identify price-cost margins using the condition (3.2) provided this system of equations is invertible, which will be the case if goods are "connected substitutes" as in Berry and Haile (2014).

We do not need to impose differentiability with respect to advertising, we only need to use the necessary first-order condition on price which depends on the observed state vector $\mathbf{a_t}$.

As shown by Dubé et al. (2005) and Villas-Boas (1993), the dynamic game can give rise to alternating strategies or pulsing strategies in advertising, corresponding to each MPE profile σ. However, the identification of marginal costs, c_{bst}, does not depend on the equilibrium value function π_j^* for a given level of observed optimal prices and advertising $(\mathbf{p_t}, \mathbf{e_t})$. So price-cost margins will depend on equilibrium strategies only through observed prices and advertising decisions, and will simply be the solution of the system of equations (3.2). The identification of marginal costs thus does not require either uniqueness of the equilibrium nor differentiability of firms' value functions.

3.2 Counterfactual Advertising Ban

We are interested in considering the impact of proposed restrictions on advertising; we consider a policy reform under which firms are banned from advertising potato chip brands. A new price equilibrium will then be played. We consider Markov equilibria where firms' strategies comprise only selection of prices. We assume that technical conditions on demand shape are satisfied to guarantee uniqueness of a Nash equilibrium in the static case (as in Caplin and Nalebuff (1991)).[7] It is straightforward to show that equilibria will satisfy the per period Bertrand-Nash conditions of profit maximization, whatever the beliefs of firms about whether the regulatory change is permanent or not. In the absence of advertising firms have no means to affect future state variables and the new price equilibrium $\mathbf{p_t^0}$ must be such that, for all (b, s) and j

$$s_{bs}\left(\mathbf{0}, \mathbf{p_t^0}\right) + \sum_{(b',s')\in F_j} \left(p_{b's't} - c_{b's't}\right) \frac{\partial s_{b's'}\left(\mathbf{0}, \mathbf{p_t^0}\right)}{\partial p_{bst}} = 0, \tag{3.3}$$

where

$$s_{bs}(\mathbf{0}, \mathbf{p_t^0}) = \int s_{ibs}(\mathbf{0}, \mathbf{p_t^0}) dF(\pi_i^u, \pi_i^o | d_i) \tag{3.4}$$

is the market level demand for product (b, s) when advertising stocks are all zero and at prices $\mathbf{p_t^0}$. We could easily obtain the counterfactual equilibrium for any other exogenously fixed levels of advertising state variables. For example, we could consider a period t_0 level of advertising state variables and simulate the subsequent period equilibria, where the advertising state vector decreases over time due to the decay of advertising, i.e. $\lim_{L\to\infty} \mathcal{A}^L\left(a_{bt-L}, 0\right) = 0$.

To evaluate the impact of an advertising ban we solve for the counterfactual pricing equilibrium in each market when advertising is banned and compare the quantities, prices, variable profits and consumer welfare relative to the equilibrium played prior to the ban (the outcome of which we observe).

[7] We can verify ex post that the equilibrium is unique.

4 Application

4.1 Data

We apply the model to the UK market for potato chips. We use two sources of data - transaction level purchase data from market research firm Kantar, and advertising data from Nielsen.

4.1.1 Purchase data

The purchase data are from the Kantar World Panel for the period June 2009 to October 2010. For each household we observe *all* food purchases made and brought into the home. We refer to these as "food at home" purchases. We also use a sample of individuals drawn from these households that record all food purchases made for consumption "on-the-go". We refer to these as "food on-the-go" purchases. Food at home purchases are by definition made for future consumption (the product has to be taken back home to be recorded), while food on-the-go purchases are made for immediate consumption. Individuals participating in the on-the-go panel include both adults and children aged 13 or older.

We use information on households (for food at home) and individuals (for food on-the-go) that we observe purchasing potato chips at least once over June 2009 to October 2010. We use information on 2872 households and 2306 individuals.

A purchase occasion is defined as a week. For the food at home segment this is any week in which the household records buying groceries; when a households does not record purchasing any potato chips for home consumption we say it selected the outside option in this segment. Potato chips are purchased on 41% of food at home purchase occasions. For the food on-the-go segment a purchase occasion is any week in which the individual records purchasing any food on-the-go; when an individual bought food on-the-go, but did not purchase any potato chips, we say they selected the outside option. Potato chips are purchased on 27% of food on-the-go purchase occasions. We use information on 161,513 food at home purchase occasions and 99,636 food on-the-go purchase occasions. From other data we know that 14% of potato chips are bought on-the-go, with the remaining share purchased for food at home (Living Cost and Food Survey).

Table 4.1: *Quantity Share and mean price*

Food at home segment

Products	Quantity Share	Price (£)
Pringles:150-300g	1.34%	1.10
Pringles:300g+	5.54%	2.63
Walkers Regular:150-300g	1.77%	1.25
Walkers Regular:300g+	23.98%	2.77
Walkers Sensations:150-300g	0.43%	1.26
Walkers Sensations:300g+	1.81%	2.52
Walkers Doritos:150-300g	1.30%	1.21
Walkers Doritos:300g+	3.29%	2.47
Walkers Other:<150g	0.69%	1.24
Walkers Other:150-300g	3.73%	1.77
Walkers Other:300g+	8.66%	3.17
KP:<150g	0.21%	0.85
KP:150-300g	4.80%	1.19
KP:300g+	14.49%	2.39
Golden Wonder:<150g	0.10%	1.28
Golden Wonder:150-300g	0.25%	1.35
Golden Wonder:300g+	1.15%	2.70
Asda:<150g	0.08%	0.93
Asda:150-300g	0.90%	0.95
Asda:300g+	2.35%	2.29
Tesco:<150g	0.18%	0.82
Tesco:150-300g	1.78%	0.91
Tesco:300g+	4.50%	2.07
Other:<150g	0.94%	1.05
Other:150-300g	3.94%	1.31
Other:300g+	11.78%	2.57

Food on-the-go segment

Products	Quantity Share	Price (£)
Walkers Regular:34.5g	27.16%	0.45
Walkers Regular:50g	7.19%	0.63
Walkers Sensations:40g	2.04%	0.61
Walkers Doritos:40g	4.70%	0.54
Walkers Other:<30g	4.34%	0.45
Walkers Other:30g+	8.94%	0.61
KP:50g	3.87%	0.57
Golden Wonder:<40g	3.08%	0.39
Golden Wonder:40g+	1.09%	0.73
Other:<40g	17.57%	0.48
Other:40g+	20.01%	0.59

Notes: Quantity share refers to the quantity share of potato chips in the segment accounted for by that product. Price refer to the mean prices across all transactions.

We define a potato chip product as a brand-pack size combination.[8] Potato chips for consumption at home are almost entirely purchased in large supermarkets as part of the households' main weekly shop,

[8] Potato chips are available in a variety of different flavours, for example, salt and vinegar or cheese and onion are popular flavours. We have this information, but we do not distinguish between these products because neither price nor advertising varies within product across flavours. For our purposes it is the choice that a consumers makes between brand and pack size that is relevant.

whereas those for consumption on-the-go are almost entirely purchased in small convenience stores. The set of products available in large supermarkets (for food at home) differs from the set of products available in convenience stores (for food on-the-go). Some brands are not available in convenience stores (for example, generic supermarket brands), and purchases made at large supermarkets are almost entirely large or multi-pack sizes, while food on-the-go purchases are almost always purchases of single packs. We restrict the choice sets in each segment to reflect this. This means that the choice sets for food at home and on-the-go occasions do not overlap; most brands are present in both segments, but not in the same pack size. Table 4.1 shows the set of products available and the market shares in each market segment. The table makes clear that Walkers is, by some distance, the largest firm in the market - its products account for 46% of all potato chips sold in the food at home segment and 54% of that sold in the food on-the-go segment. For each product we compute the transaction weighted mean price in each of the 17 months (or markets). Table 4.1 shows the mean of these market prices.

Table 4.2: *Nutrient characteristics of brands*

	Nutrient profiling score	Energy (kj per 100g)	Saturated fat (g per 100g)	Sodium (g per 100g)	Fiber (g per 100g)	Protein (g per 100g)
Pringles	16	2160	6.31	0.62	2.75	4.03
Walkers Regular	10	2164	2.56	0.59	4.04	6.11
Walkers Sensations	11	2023	2.16	0.71	4.25	5.87
Walkers Doritos	12	2095	2.86	0.66	3.02	7.47
Walkers Other	15	2020	2.50	0.82	3.14	5.46
KP	18	2158	5.87	0.85	2.70	6.35
Golden Wonder	16	2101	4.01	0.92	3.79	6.04
Asda	15	2125	4.13	0.75	3.31	5.57
Tesco	15	2145	4.65	0.77	3.57	5.97
Other	12	2084	3.84	0.70	4.06	6.02

Notes: See text for definition of the nutrient profiling score.

We are particularly interested in the nutrient characteristic of the products. We use the nutrient profile model developed by Rayner et al. (2005) (see also Rayner et al. (2009) and Arambepola et al. (2008)) and used by the UK Food Standard Agency, and the advertising regulator Ofcom to determine the healthiness of a product. The nutrient profiling model aggregates nutrient characteristic into a single score. For potato chips the relevant nutrients are the amount of energy, saturated fat, sodium and fiber that a product contains per 100g. Products get points based on the amount of each nutrient they contain; 1 point is given for each 335kJ per 100g, for each 1g of saturated fat per 100g, and for each 90mg of sodium per 100g. Each gram of fiber reduces the score by 1 point. Products may also get scores based on their fruit, sugar and protein content. All potato chips are scored zero for their fruit and sugar contents (with the exception of Walkers

Other which gets 1 point for its sugar content). Protein enters the score only if the score omitting protein is below a threshold of 11 points (which is not the case for any potato chip brand). The UK Food Standard Agency regards a product with a score of 4 points or more as 'less healthy'.

Table 4.2 shows the nutrient profile score and the nutrient values for each brand in the market. Nutrient values do not vary across pack sizes because they are measured per 100g. There is considerable variation across brands; Walkers Regular has the lowest score (10), and the brand KP has the highest score (18). This is a large difference. To give some context, if all other nutrients were the same then an 8g difference in saturated fat (per 100g or product) would lead to a difference of 8 points in the nutritional profiling score; in the UK the guideline daily amount of saturated fat is 20g per day for woman and 30g per day for men.[9]

Table 4.3: *Household types*

Demographic group			Number of		Number of purchase occasions	
			households	individuals	food at home	food on-the-go
Composition	skill level	income				
No children	high	high	472	345	22721	14371
		medium	308	235	13178	8376
		low	290	251	13341	8219
	low	medium-high	215	164	10187	6667
		low	343	258	16147	8559
Pensioners			271	145	14384	6016
Children	high	high	408	341	20426	12786
		medium	315	265	14292	8502
		low	165	139	7091	4494
	low	medium-high	323	269	15349	9549
		low	302	267	14397	8932
Child purchase				96		3165
Total			2873	2306	161,513	99,636

Notes: Households with "children" are households with at least one person aged below 18, "Pensioners" refers to a households with no more than two people, no-one aged below 18 and at least on person aged above 64; "No children" refers to all other households. "Child purchase" refers to someone aged below 18 making a food on-the-go purchase. Skill levels are defined using socioeconomic groups. "High" comprises people in managerial, supervisory or professional roles, "low" refers to both skilled and unskilled manual workers and those who depend on the state for their income. Income levels are defined by terciles of the within household type income per person distribution. The total number of households and individuals is less than the sum of the number in each category because households may switch group over time.

We allow all coefficients to vary across the demographic groups shown in Table 4.3. Households are distinguished along three characteristics: (i) household composition, (ii) skill or education level of the head

[9]Our primary interest is to estimate the impact of an advertising ban on market equilibrium, allowing for the supply response of oligopolistic firms. However, the estimates could also be used to quantify the public health effects of this policy intervention. We allow for consumer substitution away from potato chips to other products, but it is beyond the scope of this paper to estimate substitution patterns to other food categories. We are therefore unable to say whether consumers are more likely to switch to fruit (which has an average nutrient profiling score of -5) or to confectionary (which has an average nutrient profiling score of 25).

of household, based on socio-economic status, and (iii) per household member income. Table 4.3 provides details of the numbers of households of each type, the number of individuals making food on-the-go decision and the number of purchase occasions. Households and individuals can switch between demographic groups, for example if a child is born in a household, or if a grown up child turns 18.

4.1.2 Advertising data

We use advertising data collected by AC Nielsen. We have information on advertising expenditure by brand and month over the period 2001-2010. The information on earlier periods allows us to compute advertising stocks, taking into account a long period of prior advertising flows. For each brand we observe total monthly advertising expenditure, including expenditure on advertising appearing on TV, in press, on radio, on outside posters and on the internet. Advertising is at the brand level, it does not vary by pack size.

Table 4.4 describes monthly advertising expenditure by brand. Walkers spends the most on advertising. The most advertised brand is Walkers Regular with on average £450,000 expenditure per month. Walkers Regular also has the highest market share. The table shows the minimum and maximum advertising expenditures by month over the period studied. It shows that advertising expenditures varies a lot across brands, but also across months within a brand. All brands advertising strategies include some periods of zero advertising expenditure. Some brands exhibit advertising expenditures that are always close to zero, meaning that for these brands the stock of advertising is always very low.

Table 4.4: *Advertising Expenditures*

	Monthly expenditure			Total
	Mean	Min	Max	June 2009 - Oct 2010
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

Notes: Expenditure is reported in £100,000 and includes all expenditure on advertising appearing on TV, in press, on radio, on outside posters and on the internet.

Advertising in the UK potato chips market has very little informational content. The typical adverts show a sports star or a model eating potato chips. Examples are shown in Figure 4.1. The advertisement on the top left shows supermodel Elle Macpherson eating Walkers potato chips; the one on the lower left shows an ex-professional football player and TV personality Gary Lineker with the FA Cup (football) trophy full of Walkers potato chips; the top right shows one of a series of adverts for KP Hola Hoops aimed at children, and the bottom right shows a model with Golden Wonder Skins. We consider the welfare impact of a ban under the view that advertising is a characteristic valued by the consumer and under the view that advertising acts to distort consumers' choices, in the manner outlined in Section 2.2.2.

Figure 4.1: *Example adverts for potato chip brands*

Note: Adverts are for Walkers (upper left), KP Hula Hoops (upper right), Walkers (lower left) and Golden Wonder Skins (lower right).

4.2 Empirical estimates

We estimate the demand model outlined in Section 2 using simulated maximum likelihood, allowing all parameters to vary by demographic groups (defined in Table 4.3) and whether the purchase occasion is for food at home or on-the-go. We include random coefficients on brand advertising, competitor advertising, price and on a firm dummy for Walkers in the food at home segment. All random coefficients are assumed to have normal distributions, except those on price, which are assumed to be log normal. We report the full set of estimated coefficients in a Web Appendix. Here we discuss consumers' willingness to pay for nutrient characteristic, the market own and cross-price elasticities and the effect of advertising on demand, all of which are functionals of the estimated parameters.

We compute the willingness to pay for a one point reduction in the nutrient profiling score (which corresponds to an increase in product healthiness) using equation 2.3. Table 4.5 shows the median willingness to pay across households for food at home purchase occasions and across individuals for food on-the-go purchase occasions; 95% confidence intervals are given in brackets.[10] We evaluate the consumers' willingness to pays at three levels of advertising: zero, medium (corresponding to the average stock of the brand KP), and high (corresponding to the average stock of the brand Walkers Regular). When there is no advertising households are willing to pay 8.15 pence for a one point reduction in the nutrient profiling score for food at home; this falls to 7.01 pence when advertising is at a medium level, and falls further to 5.06 when advertising is at a high level. Expressed as a percentage of the mean price of potato chips available for food at home purchases, households are willing to pay an additional 4.0% for a 1 point reduction in the nutrient profiling score in the absence of advertising, this falls to 2.5% when advertising is high. A similar pattern holds for food on-the-go, with willingness to pay for a one point reduction in the nutrient profiling score falling from 4.6% of mean price to zero as advertising is raised from zero to high. Hence Table 4.5 makes clear that advertising lowers consumers' willingness to pay for an increase in the healthiness of potato chips.

Table 4.5: *Willingness to pay for 1 point reduction in nutrient profiling score*

		Advertising level		
		None	Medium	High
Food in the home	Willingness to pay in pence	8.15	7.01	5.06
		[7.58, 8.64]	[6.54, 7.38]	[4.11, 5.85]
	% of mean price	3.98	3.42	2.47
		[3.70, 4.21]	[3.20, 3.60]	[2.01, 2.86]
Food on-the-go	Willingness to pay in pence	2.31	1.19	0.06
		[2.04, 2.59]	[1.02, 1.33]	[-0.10, 0.52]
	% of mean price	4.55	2.34	0.13
		[4.02, 5.09]	[2.01, 2.62]	[-0.19, 1.02]

Notes: Numbers in rows 1 and 3 are the median willingness to pay in pence for a one point reduction in the nutrient profiling score. Numbers in rows 2 and 4 are the willingness to pay expressed as a percentage of the mean price of potato chips on the purchase occasion (i.e. food in the home or food on-the-go occasion). Medium advertising refers to the mean advertising stock of the brand KP. High advertising refers to the mean advertising level of the brand Walkers Regular. 95% confidence intervals are given in square brackets.

[10]We calculate confidence intervals in the following way. We obtain the variance-covariance matrix for the parameter vector estimates using standard asymptotic results. We then take 1000 draws of the parameter vector from the joint normal asymptotic distribution of the parameters and, for each draw, compute the statistic of interest, using the resulting distribution across draws to compute Monte Carlo confidence intervals (which need not be symmetric around the statistic estimates).

For each of the 17 markets, the demand model yields a 27×26 matrix of own and cross price elasticities between products available in the food at home segment of the market (and the outside option) and a 12×11 matrix of price elasticities between products available in the food on-the-go segment of the market (and the outside option). The mean (across markets and products) own price elasticity in the food at home segment is -2.6 and the mean in the food on-the-go segment is -3.8. Hence, on average, at observed (equilibrium) prices consumers have more elastic demand when making on-the-go purchase decisions. For brevity, in Table 4.6 we report a subset of mean market elasticities for a set of products that belong to the most popular and advertised brands.[11] The table shows that, evaluated at observed prices, larger pack sizes of a given brand tend to have more elastic demand than smaller pack sizes.

In order to illustrate the effect that advertising has on demand we do the following; for each brand in turn, we simulate what market demand would have been if that brand had zero advertising expenditure in the market (or month). In Table 4.7 we report the results for the highly advertised brands, Pringles, Walkers Regular and KP. Unilaterally shutting down Pringles' advertising results in a 17.1% reduction in the quantity demanded for that brand. Demand for Walkers Regular rises by 0.8%, but demand for all other brands falls. The overall effect is to reduce potato chip demand by 1.7%. Unilaterally shutting down Walkers Regular and KP advertising results in qualitatively similar effects, demand for most brands and total potato chips demand fall. Table 4.7 makes clear that potato chips advertising is, to a large extent, cooperative and that it leads to market expansion. The fact that we find evidence of cooperative advertising effects underlines the importance of allowing for advertising to enter demand in a flexible way that does not unduly constrain the impact of advertising on demand a priori; had we only included own brand advertising in levels in the payoff function (and omitted the interaction with price and nutrient characteristic and the competitor advertising variable), the functional form assumptions would have ruled out cooperative advertising effects.

Table 4.8 provides further insight into the effect of advertising on demand. It shows how unilaterally shutting down advertising of each of Pringles, Walkers Regular and KP affects quantity demanded for each of the pack sizes of that brand for food at home purchase. If Pringles stopped advertising their brand, monthly demand for the larger 300g+ pack size would fall by 69 times as much as demand for the smaller 150g-300g pack size. For Walkers Regular and KP, setting advertising expenditure to zero actually results in a rise in demand for the smaller pack sizes, although demand for the larger pack size falls by much more. This highlights that increasing advertising both attracts new consumers to the brand, but it also induces some consumers to trade up to larger pack sizes.

[11] We report the full matrix of price elasticities in the Web Appendix.

Table 4.6: *Selection of own and cross-price elasticities for largest brands*

	Pringles		Walkers Regular		KP		
	150-300g	300g+	150-300g	300g+	<150g	150-300g	300g+
Pringles:150-300g	**-1.4234**	0.1112	0.0630	0.2825	0.0143	0.0681	0.1711
	[-1.4841, -1.3772]	[0.1055, 0.1183]	[0.0593, 0.0678]	[0.2687, 0.2969]	[0.0137, 0.0149]	[0.0653, 0.0716]	[0.1636, 0.1785]
Pringles:300g+	0.0196	**-2.5392**	0.0412	0.3080	0.0099	0.0529	0.1883
	[0.0185, 0.0212]	[-2.6593, -2.4311]	[0.0391, 0.0437]	[0.2909, 0.3251]	[0.0095, 0.0103]	[0.0507, 0.0555]	[0.1797, 0.1973]
Walkers Regular:150-300g	0.0265	0.0987	**-1.5178**	0.3438	0.0140	0.0685	0.1812
	[0.0249, 0.0289]	[0.0935, 0.1041]	[-1.5828, -1.4630]	[0.3254, 0.3652]	[0.0135, 0.0146]	[0.0658, 0.0719]	[0.1732, 0.1886]
Walkers Regular:300g+	0.0161	0.1003	0.0448	**-2.3578**	0.0097	0.0531	0.2024
	[0.0151, 0.0172]	[0.0947, 0.1064]	[0.0424, 0.0479]	[-2.4797, -2.2568]	[0.0093, 0.0101]	[0.0508, 0.0558]	[0.1931, 0.2119]
KP:<150g	0.0205	0.0750	0.0472	0.2292	**-1.3431**	0.0794	0.1936
	[0.0194, 0.0220]	[0.0712, 0.0787]	[0.0450, 0.0498]	[0.2177, 0.2393]	[-1.3882, -1.3060]	[0.0762, 0.0834]	[0.1856, 0.2013]
KP:150-300g	0.0190	0.0778	0.0447	0.2437	0.0155	**-1.7281**	0.2047
	[0.0180, 0.0203]	[0.0741, 0.0818]	[0.0427, 0.0472]	[0.2320, 0.2553]	[0.0150, 0.0162]	[-1.7865, -1.6789]	[0.1960, 0.2135]
KP:300g+	0.0139	0.0806	0.0344	0.2697	0.0115	0.0623	**-2.8797**
	[0.0131, 0.0148]	[0.0762, 0.0853]	[0.0328, 0.0363]	[0.2547, 0.2842]	[0.0111, 0.0120]	[0.0597, 0.0655]	[-2.9922, -2.7824]
Outside option	0.0117	0.0403	0.0259	0.1203	0.0089	0.0414	0.0994
	[0.0110, 0.0124]	[0.0382, 0.0423]	[0.0248, 0.0272]	[0.1147, 0.1255]	[0.0086, 0.0093]	[0.0398, 0.0431]	[0.0954, 0.1035]

Notes: Each cell reports the price elasticity of demand for the product indicated in column 1 with respect to the price of the product in row 1. These products are all available on food at home purchase occasions, and are three of the most popular and advertised brands. Numbers are means across markets. 95% confidence intervals are given in square brackets.

Table 4.7: *Effect of advertising on brand demand*

	Pringles	Walkers Regular	KP
Advertising expenditure (£m)	0.450	0.497	0.209
% change in brand demand if advertising expenditure is set to zero			
Pringles	-17.11	3.53	-0.04
	[-18.67, -15.67]	[2.93, 4.19]	[-0.19, 0.09]
Walkers Regular	0.83	-5.93	0.41
	[0.52, 1.12]	[-7.21, -4.75]	[0.28, 0.54]
Walkers Sensations	-1.65	-2.06	-0.74
	[-1.98, -1.35]	[-2.37, -1.76]	[-0.87, -0.63]
Walkers Doritos	-0.90	-1.32	-0.68
	[-1.21, -0.59]	[-1.69, -0.94]	[-0.83, -0.54]
Walkers Other	-0.07	0.76	0.21
	[-0.38, 0.22]	[0.39, 1.11]	[0.05, 0.36]
KP	-0.95	-0.59	-2.57
	[-1.24, -0.66]	[-0.96, -0.23]	[-3.31, -1.87]
Golden Wonder	-2.03	-4.30	-1.63
	[-2.33, -1.73]	[-4.69, -3.88]	[-1.80, -1.48]
Asda	-1.37	-1.91	-0.70
	[-1.63, -1.11]	[-2.20, -1.61]	[-0.82, -0.58]
Tesco	-2.23	-3.15	-1.40
	[-2.54, -1.94]	[-3.49, -2.80]	[-1.57, -1.26]
Other	-1.20	-1.52	-0.69
	[-1.51, -0.90]	[-1.90, -1.15]	[-0.82, -0.57]
% change in total potato chips demand if advertising expenditure is set			
	-1.74	-2.07	-0.61
	[-2.00, -1.49]	[-2.34, -1.85]	[-0.72, -0.51]

Notes: For each brand in the first row, in each market, we unilaterally set current brand advertising expenditure to zero. Numbers in the table report the resulting percentage change in quantity demanded for all brands and for the potato chips market as a whole. Numbers are means across markets. 95% confidence intervals are given in square brackets.

Using the demand estimates and the price first-order condition (equation 3.2) we can infer the marginal cost of each product in each market. Tables 4.9 and 4.10 shows the implied marginal costs and margins; numbers give the mean across markets. Within the food at home segment, margins are larger for smaller pack sizes. Margins are typically lower in the food on-the-go segment than in the food at home segment. This, in part, reflects consumers' higher level of price sensitivity when buying for immediate consumptions.

Table 4.8: *Own effect of advertising on demand by pack size*

	Pringles	Walkers Regular	KP
Advertising expenditure (£m)	0.450	0.497	0.209
Change in own brand demand by pack size in 1,000kg if advertising expenditure is set to zero			
<150g			4.19
			[3.27, 5.03]
150g-300g	-4.69	63.56	15.80
	[-10.05, -0.28]	[51.85, 74.01]	[8.86, 21.86]
300g+	-323.24	-463.62	-140.83
	[-352.31, -294.90]	[-546.78, -387.27]	[-167.04, -113.83]
Change in own food at home brand demand in 1,000kg if advertising expenditure is set to zero			
	-327.92	-400.06	-120.83
	[-361.47, -295.62]	[-490.70, -314.40]	[-154.66, -88.67]

Notes: For each brand in the first row, in each market, we unilaterally set current brand advertising expenditure to zero. Numbers in the table report the change in quantity demands for all pack sizes of the brand available on food at home purchase occasions. Numbers are means across markets. 95% confidence intervals are given in square brackets.

Table 4.9: *Marginal costs: food at home segment*

	Price (£)	Cost (£)	Margin
Pringles:150-300g	1.11	0.28	0.75
		[0.26, 0.32]	[0.71, 0.77]
Pringles:300g+	2.61	1.54	0.41
		[1.49, 1.59]	[0.39, 0.42]
Walkers Regular:150-300g	1.25	0.12	0.91
		[0.07, 0.17]	[0.87, 0.95]
Walkers Regular:300g+	2.79	1.32	0.53
		[1.25, 1.39]	[0.50, 0.55]
Walkers Sensations:150-300g	1.30	0.41	0.70
		[0.39, 0.45]	[0.68, 0.72]
Walkers Sensations:300g+	2.58	1.53	0.41
		[1.49, 1.57]	[0.39, 0.42]
Walkers Doritos:150-300g	1.21	0.28	0.77
		[0.25, 0.31]	[0.75, 0.80]
Walkers Doritos:300g+	2.50	1.39	0.45
		[1.35, 1.43]	[0.43, 0.46]
Walkers Other:<150g	1.24	0.23	0.82
		[0.20, 0.27]	[0.78, 0.84]
Walkers Other:150-300g	1.77	0.68	0.62
		[0.64, 0.72]	[0.60, 0.64]
Walkers Other:300g+	3.18	1.86	0.42
		[1.80, 1.91]	[0.40, 0.43]
KP:<150g	0.86	0.14	0.85
		[0.12, 0.16]	[0.82, 0.87]
KP:150-300g	1.19	0.44	0.64
		[0.41, 0.46]	[0.61, 0.65]
KP:300g+	2.39	1.51	0.37
		[1.48, 1.54]	[0.36, 0.38]
Golden Wonder:<150g	1.26	0.66	0.49
		[0.64, 0.69]	[0.47, 0.51]
Golden Wonder:150-300g	1.40	0.80	0.44
		[0.78, 0.82]	[0.43, 0.46]
Golden Wonder:300g+	2.78	2.08	0.25
		[2.06, 2.11]	[0.24, 0.26]
Asda:<150g	0.94	0.18	0.82
		[0.14, 0.20]	[0.79, 0.85]
Asda:150-300g	0.95	0.20	0.79
		[0.17, 0.23]	[0.76, 0.83]
Asda:300g+	2.28	1.44	0.37
		[1.41, 1.48]	[0.36, 0.39]
Tesco:<150g	0.82	0.24	0.72
		[0.22, 0.26]	[0.70, 0.74]
Tesco:150-300g	0.91	0.32	0.65
		[0.30, 0.34]	[0.63, 0.67]
Tesco:300g+	2.06	1.39	0.33
		[1.37, 1.41]	[0.32, 0.34]
Other:<150g	1.05	0.31	0.70
		[0.29, 0.34]	[0.68, 0.72]
Other:150-300g	1.31	0.56	0.58
		[0.53, 0.59]	[0.55, 0.59]
Other:300g+	2.57	1.69	0.34
		[1.66, 1.73]	[0.33, 0.35]

Notes: Margins are defined as $(p - mc)/p$. Numbers are means across markets. 95% confidence intervals are given in square brackets.

Table 4.10: *Marginal costs: food on-the-go segment*

	Price (£)	Cost (£)	Margin
Walkers Regular:34.5g	0.45	0.26	0.42
		[0.25, 0.27]	[0.40, 0.44]
Walkers Regular:50g	0.63	0.43	0.33
		[0.42, 0.44]	[0.31, 0.34]
Walkers Sensations:40g	0.62	0.42	0.33
		[0.41, 0.43]	[0.31, 0.35]
Walkers Doritos:40g	0.54	0.35	0.35
		[0.35, 0.37]	[0.33, 0.36]
Walkers Other:<30g	0.45	0.27	0.41
		[0.26, 0.28]	[0.38, 0.42]
Walkers Other:30g+	0.61	0.41	0.32
		[0.41, 0.43]	[0.30, 0.33]
KP:50g	0.57	0.45	0.22
		[0.44, 0.45]	[0.20, 0.23]
Golden Wonder:<40g	0.39	0.24	0.38
		[0.23, 0.25]	[0.35, 0.40]
Golden Wonder:40g+	0.73	0.53	0.27
		[0.52, 0.55]	[0.24, 0.29]
Other:<40g	0.48	0.31	0.35
		[0.30, 0.32]	[0.33, 0.37]
Other:40g+	0.58	0.41	0.29
		[0.41, 0.42]	[0.28, 0.31]

Notes: Margins are defined as $(p - mc)/p$. Numbers are means across markets. 95% confidence intervals are given in square brackets.

4.3 Counterfactual analysis of advertising ban

We first discuss the impact of an advertising ban on market equilibria. These numbers are robust to whether we view advertising as informative about product characteristics, a characteristic in itself, or as persuading consumers to make suboptimal choices. We then discuss the impact of the ban on welfare, where the conclusions dependent on which view of advertising is adopted.

4.3.1 Impact on market equilibrium

Table 4.11 presents a summary of the overall impact of an advertising ban on total monthly expenditure on potato chips, the total quantity of potato chips sold, the average nutrient score of potato chips purchased and total variable profits.[12] The first column shows the average of each variable across markets prior to

[12] To gross the numbers up from our sample to the UK market we need a measure of the total market size M_t and how it is split between food at home and food on-the-go segments. From the Snack, Nut and Crisp Manufacturers Association we know that 332,239 tonnes of savoury snacks were sold in the UK in 2011 (http://www.snacma.org.uk/fact-or-fiction.asp) and from the Living Cost and Food Survey we know that 14% of potato chips by volume were purchased as food on-the-go. Based on this information and the average pack size of potato chips and purchase share of the outside option in each segment, we can compute the implied size of each segment of the market.

the ban, the second column shows numbers following the ban when prices are held constant, and the final column shows numbers in the post-ban equilibrium when firms are allowed to reoptimize their prices.

Table 4.11: *Effects of a ban on advertising*

	Pre ban	Post ban	
		No firm response	With firm response
Expenditure (£m)	201.54	162.91	172.06
	[197.84, 203.46]	[154.50, 169.49]	[164.02, 178.44]
% change		-19.17	-14.63
		[-23.08, -15.29]	[-18.28, -11.04]
Quantity (m kg)	30.01	23.37	28.37
	[29.46, 30.38]	[22.15, 24.52]	[26.84, 29.59]
% change		-22.12	-5.48
		[-25.86, -18.10]	[-9.96, -1.00]
Nutrient score	13.68	13.37	13.06
	[13.66, 13.71]	[13.31, 13.45]	[12.98, 13.14]
% change		-2.27	-4.58
		[-2.76, -1.75]	[-5.11, -4.00]
Profits (£m)	88.17	75.37	75.12
	[83.74, 91.76]	[70.05, 79.56]	[69.98, 78.99]
% change		-14.52	-14.80
		[-18.71, -9.99]	[-18.67, -10.75]

Notes: Percentage changes are shown below variables. "No firm response" refers to the situation where advertising is banned and prices are held at their pre ban level; "Firm response" refers to the situation where advertising is banned and firms reoptimize their prices. Expenditure refers to total expenditure on potato chip, quantity refers to the total amount of potato chips sold and profits are total variable profits. Nutrient score reports the mean nutrient profiling score for potato chip purchases; a reduction indicates consumers are switching to more healthy potato chips. Numbers are means across markets. 95% confidence intervals are given in square brackets.

Prior to the ban total monthly expenditure on potato chips was £202m and total quantity sold was 30m kg. The impact of the ban if we hold prices constant is to induce a 19% fall in expenditure and a 22% fall in quantity sold. The average nutrient profiling score of potato chips purchased would fall by 2% (meaning consumers switch to products that have a lower nutrient score) and variable profits would fall by around 15%. The impact differs when we account for the fact that oligopolistic firms will respond to the advertising ban by adjusting prices. In equilibrium, expenditure falls by 15% but total quantity sold falls by only 5%. The reason (shown below) is that firms respond to the advertising ban by lowering price (on average). The pattern of price response leads to a larger fall in the nutrient profiling score (of 5%), as people are led to switch even more strongly to brands with lower nutrient profiling scores. The effect of firm reoptimization on aggregate variable profits is small; as in the no firm response case, they fall by around 15%.

Table 4.12: *Advertising ban: Impact by firm*

	Pringles	Walkers	KP	Golden Wonder	Asda	Tesco	Other
Pre ban							
Advertising expenditure (£m)	0.450	1.014	0.209	0.008	0.001	0.008	0.157
Price (£)	1.86	1.77	1.46	1.47	1.39	1.27	1.40
	[1.86, 1.86]	[1.77, 1.78]	[1.45, 1.46]	[1.44, 1.49]	[1.39, 1.39]	[1.27, 1.27]	[1.40, 1.41]
Quantity (m kg)	1.94	13.66	4.97	0.54	1.26	1.67	5.97
	[1.87, 2.00]	[13.34, 13.87]	[4.85, 5.07]	[0.52, 0.57]	[1.19, 1.35]	[1.61, 1.73]	[5.81, 6.08]
Profits (£m)	5.07	49.56	11.51	1.34	3.07	3.16	16.98
	[4.74, 5.40]	[46.70, 51.90]	[10.99, 11.93]	[1.24, 1.44]	[2.84, 3.36]	[3.00, 3.32]	[16.05, 17.60]
Post ban: No firm response							
% change in quantity	-41.03	-17.66	-28.78	-34.31	-25.35	-33.78	-14.67
	[-44.88, -36.90]	[-21.83, -13.48]	[-33.16, -24.02]	[-37.99, -30.04]	[-29.31, -21.12]	[-37.85, -29.23]	[-18.77, -10.26]
% change in profits	-31.49	-12.19	-25.53	-36.02	-26.32	-34.81	-11.84
	[-36.03, -26.50]	[-16.62, -7.73]	[-30.29, -20.34]	[-39.71, -31.63]	[-30.30, -22.02]	[-38.90, -30.32]	[-16.24, -7.21]
Post ban: With firm response							
% change in price	-15.09	-9.12	-8.04	-1.91	-1.83	0.32	-7.05
	[-16.58, -13.59]	[-10.15, -8.00]	[-8.81, -7.34]	[-3.96, 0.05]	[-2.68, -0.84]	[-0.17, 0.87]	[-8.22, -5.76]
% change in quantity	-21.11	17.53	-26.62	-42.44	-32.91	-44.38	-16.35
	[-26.55, -14.77]	[11.57, 23.24]	[-30.86, -21.97]	[-45.78, -38.62]	[-36.31, -29.10]	[-47.83, -40.58]	[-20.28, -12.36]
% change in profits	-36.61	-7.17	-34.73	-39.73	-35.56	-44.83	-17.81
	[-40.81, -31.93]	[-11.43, -2.89]	[-38.51, -30.38]	[-43.48, -35.51]	[-38.83, -31.60]	[-48.11, -41.09]	[-22.25, -13.82]

Notes: "No firm response" refers to case of an advertising ban when prices are held at their pre ban level; "Firm response" refers to case of an advertising ban when firms reoptimize their prices. Price refers to the quantity weighted mean price set by the firm, quantity refers to the total amount of produce sold and profits are variable profits. Numbers are means across markets. 95% confidence intervals are given in square brackets.

Table 4.12 disaggregates the impact of the ban by firm and reports the average impact of the ban across months. The first panel reports pre ban numbers, showing mean advertising expenditures, the average price, total quantity of potato chips and total variable profits. The second panel details the percent change in quantity sold and variable profits resulting from the ban if firms do not reoptimize their price in response. The final panel shows the impact on prices, quantity and variable profits following the ban in equilibrium, when firms are allowed to reoptimize prices.

When prices are held at their pre ban level the ban leads to fall in the quantity sold and variable profits of each firm in the market. In the counterfactual market equilibrium all firms (with the exception of Tesco) reduce their average price. The biggest advertisers, Pringles, Walkers and KP, reduce their prices the most. In equilibrium, all firms still experience a reduction in variable profits relative to the pre ban case, but unlike the other firms, Walkers, the largest firm in the market, sells more than prior to the ban. This is, in part, driven by the fact that Walkers responds to the ban by aggressively lowering the prices of its most popular brand, Walkers Regular (reducing the price of the 150-300g pack by 28% and the 300g+ pack by 19%). Walkers is the only firm that benefits from the post-ban reoptimization of prices, in the sense that it sees a lower fall in variable profits when firms are allowed to reoptimize prices compared to when prices are held at their pre ban level. For other firms in the market the opposite is true. Walkers variable profits fall by less in percentage terms than the smaller firms operating in the market.

In Table 4.13 we summarize the impact of the advertising ban on the amount of potato chips the average consumer purchases in a year, and on the average nutrient profiling score of these purchases. The table separates purchases made for food at home, and purchases made on-the-go for immediate consumption. In the food at home segment banning advertising reduces the quantity of potato chips that households buy, and it leads them to switch to healthier products. The impact of firms' pricing response is to mitigate the reduction in quantity, but to reinforce the switch to healthier products within the market. In the food on-the-go segment the ban also leads to a reduction in potato chips purchases and a switch to less unhealthy brands. But in contrast to the food at home segment, it is the price response of firms that is crucial in driving the fall in quantity (as prices for products available for food on-the-go actually rise on average).

Table 4.13: *Impact of ban on consumers' annual potato chips purchases*

	Food at home	Food on-the-go
Pre ban		
Quantity (kg per year)	7.21	0.52
	[7.07, 7.31]	[0.50, 0.52]
Mean nutrient score	13.83	12.52
	[13.81, 13.86]	[12.48, 12.55]
Post ban: No firm response		
% change in quantity	-25.16	1.04
	[-29.09, -20.86]	[-5.54, 6.52]
% change in nutrient score	-1.88	-2.20
	[-2.33, -1.40]	[-2.90, -1.39]
Post ban: With firm response		
% change in quantity	-5.24	-6.58
	[-9.94, -0.70]	[-12.89, -0.91]
% change in nutrient score	-4.66	-2.72
	[-5.18, -4.08]	[-3.46, -1.89]

Notes: "No firm response" refers to case of an advertising ban when prices are held at their pre ban level; "Firm response" refers to case of an advertising ban when firms reoptimize their prices. Quantity refers to the total amount of potato chips produce purchased. Nutrient score reports the mean nutrient profiling score for inside option purchases; a reduction indicates consumers are switching to less unhealthy potato chips produce. Numbers are the mean value for a consumer for a one year period. 95% confidence intervals are given in square brackets.

4.3.2 Impact on welfare

Table 4.14 summarizes the impact of the ban on welfare. Compensating variation depends on the perspective one takes about advertising. As discussed in Section 4.1.2, advertising in the UK potato chips market does not contain much informative content, so we argue that it is reasonable to think of advertising either as a product characteristic that is valued by the consumers (and therefore enters the utility function), or as acting to distort consumer decision making. In Section 2.2 we outlined how these alternative views of advertising can be accommodated in our model when making statements about changes in consumer welfare. We report welfare numbers under the two extreme scenarios that advertising is only a characteristic, or that its only role is to distort choices; as made clear in Section 2.2 it is straightforward to accommodate intermediate possibilities. Conclusions about whether the advertising ban is welfare improving will ultimately rest on which view of advertising the policymaker finds most appropriate.

The top panel of Table 4.14 shows changes in welfare resulting from the advertising ban under the view that advertising is a characteristic. It reports the "characteristic effect", which measures the direct effect on consumer welfare resulting from removing advertising; the "price competition effect", which measure the impact on consumer welfare from firms reoptimizing their prices in response to the ban; total compensating variation, which is the sum of the characteristic and price competition effects; the change in firms' variable profits; and the total change in welfare (the sum of compensating variation and the change in variable profits). The first column reports values when prices are held fixed and the second column gives numbers when firms repotimize their prices in response to the ban. The "characteristic effect" leads to a £48 million fall (per month) in consumer welfare. Under this view consumers place positive value on advertising, and its removal reduces their welfare.[13] The "price competition effect" (which is only present when firms are allowed to reoptimize their prices), acts to raise consumer welfare by £14 million. Firms, on average, respond to the ban by lowering their prices and consumers benefit from facing these lower prices. However, the characteristic effect dominates, meaning total compensating variation is negative. The ban also leads to a fall in firms' variable profits, meaning that under the characteristic view of advertising, the effect of the ban is to lower total welfare (not accounting for any potential health benefits arising from the ban).

Table 4.14: *Effect of ban on welfare*

	Post ban	
	No firm response	With firm response
Advertising as a characteristic		
Characteristic effect (£m)	-48.00	-48.00
	[-54.14, -41.21]	[-54.14, -41.21]
Price competition effect (£m)	0.00	14.22
		[12.00, 16.45]
Total compensating variation (£m)	-48.00	-33.78
	[-54.14, -41.21]	[-40.21, -26.62]
Change in profits (£m)	-12.80	-13.05
	[-16.57, -8.64]	[-16.50, -9.30]
Total change in welfare (£m)	-60.80	-46.83
	[-70.60, -49.96]	[-56.84, -36.31]
Advertising as distorter of choice		
Choice distortion effect (£m)	33.21	33.21
	[31.77, 36.37]	[31.77, 36.37]
Price competition effect (£m)	0.00	14.22
		[12.00, 16.45]
Total compensating variation (£m)	33.21	47.43
	[31.77, 36.37]	[45.31, 51.41]
Change in profits (£m)	-12.80	-13.05
	[-16.57, -8.64]	[-16.50, -9.30]
Total change in welfare (£m)	20.41	34.38
	[17.96, 24.54]	[31.45, 38.96]

Notes: "No firm response" refers to case of an advertising ban when prices are held at their pre ban level; "Firm response" refers to case of an advertising ban when firms reoptimize their prices. We compute compensating variation under two different views of the impact of advertising, as outlined in Section (2.2). For the demographic groups 'Pensioners' and 'Children, high skill level, low income' the compensating variation numbers for food on-the-go purchase occasions are instable. We therefore omit such purchase occasions (which account for 4% of the total) when computing aggregate compensating variation. Numbers are means across markets. 95% confidence intervals are given in square brackets.

[13] Note it is not automatically the case that the "characteristic effect" will lead to a fall in consumer welfare; it is possible that consumers place negative value on advertising, and strategic considerations could still mean that it is optimal for firms to have non-zero advertising.

The bottom panel of Table 4.14 presents changes in welfare resulting from the advertising ban under the alternative view that advertising acts to distort consumer decision making. In this case, total compensating variation includes the "price competition effect", as above, plus the "choice distortion effect", which captures the fact that advertising induces consumers to make distorted decisions, and the ban removes this distortion. We estimate that the welfare gain from removing potentially distorting advertising is £33 million. Coupled with the benefit consumers get from facing lower prices, total compensating variation (in the post ban equilibrium) is £47 million. This outweighs the fall in firms' variable profits, meaning that under the distortionary view of advertising, an advertising ban is welfare improving.

We define total welfare as the sum of compensating variation and the change in firms' variable profits. It does not include possible future benefits (or costs) to consumers of better health resulting from lower potato chips consumption. Nor does it include general equilibrium effects on markets other than the potato chip market (such as the advertising market). If, for instance, the future health benefits from lower potato chip consumption and the switch to healthier potato chip products induced by the advertising ban are sufficiently large, they may lead the advertising ban to be welfare improving even under the characteristic view of advertising.

5 Summary and conclusions

In this paper we develop a model of demand and supply in a market where firms compete over prices and advertising budgets, and where the impact of current advertising on future demand means that each firm's problem is a dynamic one. We allow advertising to impact demand in a flexible way, which allows us to understand the impact of advertising on demand while remaining agnostic about the view taken of advertising (as informative, a characteristic or persuasive), and we do not rule out a priori that advertising is cooperative and leads to market expansion or that it is predatory and possibly leads to market contraction. We apply the model to the potato chip market using novel transaction level data on purchases of food taken into the home and food bought on-the-go for immediate consumption. We find that brand advertising increases both own demand and often competitor demand, suggesting that it is, at least in part, cooperative. As well as attracting new customers, higher brand advertising also induces consumers to trade up to larger pack sizes and it lower consumers' willingness to pay for healthier produce.

We use the structural model to simulate the impact of an advertising ban on market equilibrium. This both helps us understand the impact that advertising has on equilibrium outcomes, and given recent calls for restrictions in junk food advertising, is an interesting exercise from a policy perspective. We find that banning advertising lowers potato chip demand, but this effect is partially mitigated by the fact that firms respond to the ban by lowering their prices. Nevertheless, the overall impact of the ban is to lower the total amount of potato chips sold.

Ultimately we are interested in the impact of the ban on welfare. Welfare considerations are complicated by their dependence on how one views the role of advertising. In the potato chip market, as in many junk food markets, advertisements have little informational content. We therefore consider a number of alternative ways that welfare could be evaluated, depending on the view one takes of advertising. We present results for two views - that advertising is either a characteristic valued by consumers, or it acts to make consumers take decisions that are inconsistent with their underlying preferences. We show that welfare conclusions depend on which view of advertising one finds more convincing; if advertising acts to distort decision-making, consumer and total welfare rise; if advertising is a characteristic, consumer and total welfare fall.

In this paper our focus has been on the impact of an advertising ban on a market with a set of well established and known brands. An interesting avenue for future research would be to consider an alternative counterfactual; for instance how would firms' pricing and advertising strategies respond to the introduction of a tax. The framework we develop in this paper could potentially be used to study such a question, although solving for the set of counterfactual equilibria would present considerable challenges. In markets with a reasonable degree of product churn, entry and exit considerations may play a more prominent role than in the potato chips market. In such a case, the ex ante evaluation of an advertising ban could be extended to study the effects of a ban on industry structure. Advertising may constitute a barrier to entry, and banning advertising may facilitate entry of competitors who would not need to invest in building up large advertising stocks. While in the particular market studied in the paper, this consideration is not of first-order concern, in other less mature markets it may be more important. This represents a promising direction for future research.

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