The Effects of Banning Junk Food Advertising

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Abstract

We develop a structural model to analyze the effect of banning advertising on market equilibria and welfare in junk food markets. We consider the impact on demand and prices, and we show how to quantify welfare effects when advertising might lead consumers to take decisions that are inconsistent with their underlying preferences. We use transaction level data on the potato chips market and find that banning advertising leads to a direct reduction in demand, but also toughens price competition, leading to lower prices and increased demand. Welfare increases as consumers benefit from no longer making distorted decision and lower prices.

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 banning junk food advertising. We develop a model of consumer demand and oligopoly supply in which multi-product firms compete in prices and advertising budgets. We pay careful attention to the way that advertising affects demand, allowing advertising of one brand to potentially increase or decrease demand for other brands, and for past advertising to influence current demand, meaning firms play a dynamic game. We use the model to simulate counterfactual market equilibria in which advertising is banned. Banning advertising leads to a direct reduction in quantity demanded, but it also leads to tougher price competition; the decrease in equilibrium prices leads to an offsetting increase in quantity demanded.

The ban has a substantial welfare effect. The affect of banning advertising on consumer welfare depends on the view one takes about how advertising affects consumers' decision making, and specifically whether advertising enters utility or not. Most advertising in junk food markets involves celebrity endorsements of established brands. If we consider this to lead consumers to make choices that are inconsistent with their underlying preferences, and not to enter utility directly, this leads consumers to maximize an objective function that differs from their true underlying utility, reflecting the distinction between decision utility and experienced utility (Kahneman et al. (1997)). Removing advertising leads to welfare gains because consumers' decisions are no longer distorted, and tougher price competition increases consumer welfare. On the other hand, if advertising enters utility directly then consumers are made worse off by the ban.

Advertising is regulated in many markets (for example in the cigarette and tobacco and alcohol 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, particularly by children. The World Health Organization ((WHO, 2010)) published the recommendation that the "overall policy objective should be to reduce both the exposure of children to, and the power of, marketing of foods high in saturated fats, *trans*-fatty acids, free sugars, or salt". 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, a ban on advertising could lead the market to expand or to contract. Brand 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

[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).

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.

To illustrate these effects we apply our model to the market for potato chips using 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. The potato chips market is interesting because it is an important source of junk calories, but we also believe that the results that we obtain speak to the effects of advertising in a broader set of junk food markets where advertising plays a similar role and where market structures are of a similar nature. In concentrated markets where advertising is not informative, advertising is likely to dampen price competition between firms, and therefore banning it leads to lower equilibrium prices. These lower prices stimulate demand, and so mitigate the direct effects of banning adverting. The effects on consumer welfare depend on whether advertising enters utility directly; if it does then banning it may lead to a reduction in consumer welfare, however, if the main effects of advertising are to distort consumer decision making then banning is likely to lead to welfare gains.

There is a large literature on how advertising affects consumer choice. Bagwell (2007) provides a comprehensive survey and makes a useful distinction between advertising as being persuasive, entering utility directly as a characteristics, or being informative. Much of 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 explored 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, causing 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, choices based on the advertising cues are based on improperly processed information, and therefore welfare should be based on choice made under other conditions. We follow this idea and argue that we can identify and empirically estimate undistorted

[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.

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. We find that banning advertising is welfare enhancing. In a theoretical paper, Glaeser and Ujhelyi (2010) make a similar finding; they consider some advertising in the food market as misinformation that leads consumers to consume an unhealthy good excessively and argue that a quantity restriction on advertising can maximize welfare.

An alternative 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 a characteristic that enters the utility function. The crucial feature that distinguishes this characteristic view of advertising from the persuasive view is how advertising effects 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.

Another branch of the literature focuses on the role that advertising plays in providing information to consumers (as distinct from being persuasive). For instance, advertising may inform consumers about the quality or characteristics of a product (Stigler (1961) and Nelson (1995)), product price (for instance, see Milyo and Waldfogel (1999) who study the alcohol market), or 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 actually have an incentive to limit the informative content of adverts even when consumers are imperfectly informed (see also Spiegler (2006)). We discuss the content of advertising in junk food markets, and in our view they have little informative content.

There is a vast empirical literature estimating the impact of advertising on demand; Bagwell (2007) provides a survey of some of the relevant literature. Most relevant to us are Qi (2013) and Seldon and Doroodian (1989) who estimate the effect of bans on cigarette advertising.

Our work also relates to the growing dynamic games literature in empirical IO. Like the vast majority of the literature, we use Markov-Perfect Nash equilibrium (MPNE), as in Maskin and Tirole (1988) and Ericson and Pakes (1995). Existing work in the dynamic game literature on the impact of advertising on market equilibria has focused on simulating the effect of advertising on market structure in a stylized setting. For instance, Doraszelski and Markovich (2007) 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 and 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)).

Much of the broader dynamic games literature has been interested in addressing the substantial computational burden of estimating 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 specify 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, meaning it is sufficient to focus on the static price first-order conditions. 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 acts expands the market, or that it is predatory and so potentially contracts the market. We also detail how we can evaluate the impact of advertising on consumer welfare. Section 3 presents a dynamic oligopoly model in which multi-product firms compete in price and advertising budgets 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. Section 4.2 describes our estimates and Section 4.3 describes market equilibria with advertising and with an advertising ban implemented. 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 transaction level data. Berry and Haile (2010, 2014) show that identification of such multinomial choice models requires less restrictive assumptions with micro data, compared with when market level data alone are 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.

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 state 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.

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, $\alpha_i\left(\mathbf{a_{bt}},p_{bst}\right)$, a term reflecting the net impact of the nutritional content of the product on the payoff function, $\psi_i\left(\mathbf{a_{bt}},x_b\right)$, 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:

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

where we specify the functions:

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

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 $\pi_i^o = (\alpha_{1i}, \psi_{0i}, \psi_{1i}, \eta_{1i}, \eta_{2i})$ 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 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.

When we specify and estimate the demand system we can remain agnostic about how advertising affects demand (in Bagwell (2007)'s terms whether it is informative about product characteristics, persuasive or a characteristic). Advertising might 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 stand on the role of advertising.

Without further restrictions, we cannot separately identify the baseline nutrient characteristic coefficient (ψ_{0i}) from the unobserved brand effect (ξ_b), although we can identify the combination of the two effects:

$\zeta_{ib} = \psi_{0i} x_b + \eta_{3i}\xi_b$. To simulate the equilibrium and welfare effects of an advertising ban, it is not necessary to separately estimate these coefficients. However, we are able 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:

$$\bar{v}_{i00t} = \zeta_{i0t} + \epsilon_{i00t}.$$

We allow the mean utility of the outside option, ζ_{i0t} to change over time. In particular, we allow it to change from year to year and seasonally.

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:

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

The payoff function (2.1) allows advertising to have a flexible impact on demand in an empirically tractable way. By allowing advertising to shift the marginal effect of price and the marginal effect of the nutrient characteristic on the payoff function, we allow advertising to have a direct impact on price elasticities and the consumer's willingness to pay for a change in the nutrient characteristic. Crucially, the inclusion of competitor advertising in the payoff function allows the model to capture both predatory and cooperative advertising. In particular, the specification is sufficiently flexible to 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 we say advertising of brand b is cooperative with respect to brand b'. Conversely, the specification also allows for the possibility that an increase in the advertising state variable for brand b reduces demand for brand b' - in which case we say advertising of brand b is predatory with respect to brand b'. In addition, the way we include advertising allows for the possibility that the size of the total market can either expand or contract in response to an increase in the brand b advertising state. Had we only included brand advertising as the only advertising variable in the payoff function we would have restricted, a priori, advertising to be predatory and to lead to market expansion.[4]

[4] We report the marginal own and cross advertising effects in the Appendix.

2.2 Consumer Welfare

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, to understand 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] requires that we take a stance on which view of advertising is most appropriate.

Advertising in the UK potato chips principally consists of celebrity endorsements (see Section 4.1.2). This is true of much advertising in consumer goods markets, and particularly in junk food markets. We adopt the view that advertising is persuasive and acts to distort consumer decision making. The persuasive view of advertising has a long tradition in the advertising literature (Robinson (1933), Kaldor (1950)). More recently, the behavioral economics literature (see Bernheim and Rangel (2005)) has suggested 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 if the environmental cues have information content, persuasive advertising might distort choices in ways that do not enhance welfare. Bernheim and Rangel (2009) argue that *" 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."* The welfare implications of restricting advertising that acts to distort decision making has been explored by Glaeser and Ujhelyi (2010), who are particularly concerned with firm advertising (or misinformation in their term) in food markets, while Mullainathan et al. (2012) consider the broad policy framework in public finance applications when consumers makes decisions inconsistent with their underlying welfare.

As pointed out by Dixit and Norman (1978), the welfare effects of changes in advertising will depend on whether one uses pre or post tastes to evaluate welfare. When assessing the welfare implications of banning persuasive advertising it is natural to assess welfare changes using undistorted preferences (i.e. the parameters in the consumer's payoff function in the absence of advertising). This mirrors the distinction made by Kahneman et al. (1997) between decision and experience utility; in his terms, advertising affects choice and therefore decision utility, but it not does not affect underlying or experience utility.

Under the persuasive 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 $\bar{v}_{ibst}$ as in equation (2.1), but the true underlying utility is based

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

on the consumer's product valuation in the absence of advertising:

$$\widehat{v}_{ibst} = \alpha_i\left(\mathbf{0}, p_{bst}\right) + \psi_i\left(\mathbf{0}, x_b\right) + \gamma_i(\mathbf{0},\mathbf{0}) + \eta_i(\mathbf{z_{bs}}, \xi_b) + \epsilon_{ibst}. \tag{2.3}$$

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 (2.3):

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

Noting that

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

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:

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

where s_{ibst} is given by equation (2.2) and, up to an additive constant,

$$\begin{aligned}
W_i\left(\mathbf{a_t}, \mathbf{p_t}\right) \equiv & E_\epsilon\left[\max_{(b,s)\in\Omega_\kappa} \bar{v}_{ibst}\right] \\
= & \ln\left[\sum_{(b\neq 0, s\neq 0)\in\Omega_\kappa} \exp\left[\alpha_i\left(\mathbf{a_{bt}}, p_{bst}\right) + \psi_i\left(\mathbf{a_{bt}}, x_b\right) + \gamma_i(\mathbf{a_{bt}}, \mathbf{a_{-bt}}) + \eta_i(\mathbf{z_{bs}}, \xi_b)\right] + \exp\left[\zeta_{i0t}\right]\right]
\end{aligned} \tag{2.4}$$

using the standard closed form (Small and Rosen (1981)) when the error term ϵ is distributed type I extreme value.

This says that when a consumer's choices are distorted by advertising, expected utility is equal to expected utility if advertising was in the consumer's utility function, minus a term reflecting the fact that the consumer is making choices that do not maximize her true underlying utility function.

Denote a counterfactual equilibrium in which there is no advertising by $(\mathbf{0}, \mathbf{p}^0)$; we define the nature of this equilibrium more precisely in Section 3.2. Evaluating the impact of banning advertising under the welfare standard of $\widehat{v}_{ibst}$, the consumer welfare difference between the equilibrium with advertising and the one in which advertising is banned can be decomposed as:

$$\begin{aligned} W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - \widehat{W}_i\left(\mathbf{a_t}, \mathbf{p_t}\right) = & W_i\left(\mathbf{0}, \mathbf{p_t}\right) - \widehat{W}_i\left(\mathbf{a_t}, \mathbf{p_t}\right) \quad \text{(choice distortion effect)} \\ & + W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - W_i\left(\mathbf{0}, \mathbf{p_t}\right) \quad \text{(price competition effect)} \end{aligned} \tag{2.5}$$

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

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". However, banning advertising also affects consumer welfare through the "price competition effect" channel. The sign of this effect will depend on the change in pricing equilibrium. The price competition effect is independent of the view we take about advertising since firms' behavior depends only on decision utilities of consumers.

An alternative to the persuasive view of advertising is that it is a characteristic of the product that consumers value (Stigler and Becker (1977) and Becker and Murphy (1993)). In this case, in the terminology of Kahneman et al. (1997), advertising would enter both experience and decision utilities. The welfare effect of banning advertising would be given by the more standard term $W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - W_i\left(\mathbf{a_t}, \mathbf{p_t}\right)$ and the choice distortion term in the equation (2.5) would be replaced by a term reflecting the impact on welfare of removing the advertising characteristic from the market, $W_i\left(\mathbf{0}, \mathbf{p_t}\right) - W_i\left(\mathbf{a_t}, \mathbf{p_t}\right)$. Identification of this effect is influenced by the normalization of outside option utility. We include own brand and competitor advertising in the payoff function of inside goods. An alternative specification that would give rise to observationally equivalent demand is if own brand advertising appears in the payoff of inside goods, and total advertising appears in the payoff of the outside option. However, these two specifications will lead to different welfare predictions under the characteristics view.[6] Under the persuasive view of advertising, advertising does not enter the utility function and therefore the indeterminacy does not exist.

We focus on welfare measures of the direct monetary net costs for consumers and firms of an advertising ban. To measure the monetary net costs to a consumer we convert the welfare changes to compensating variation (dividing by the marginal utility of income):

$$CV_i\left(\mathbf{a_t}, \mathbf{p_t}, \mathbf{p_t^0}\right) = \frac{1}{\alpha_{0i}}\left[W_i\left(\mathbf{0}, \mathbf{p_t^0}\right) - \widehat{W}_i\left(\mathbf{a_t}, \mathbf{p_t}\right)\right] \tag{2.6}$$

[6] See the Appendix for details.

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 of 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.

2.3 Market Demand

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:

$$s_{bs}(\mathbf{a_t}, \mathbf{p_t}) = \int s_{ibs}(\mathbf{a_t}, \mathbf{p_t}) dF(\pi_i^u, \pi_i^o | d_i). \tag{2.7}$$

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, aggregate compensating variation is given by;

$$CV\left(\mathbf{a_t}, \mathbf{p_t}, \mathbf{p_t^0}\right) = \int CV_i\left(\mathbf{a_t}, \mathbf{p_t}, \mathbf{p_t^0}\right) dF(\pi_i^u, \pi_i^o | d_i). \tag{2.8}$$

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 of price by controlling for market varying product effects using an auxiliary IV regression. Our strategy differs from the typical "BLP" approach and is similar to that suggested in Bajari and Benkard (2005); we exploit the richness of our micro data, and the fact that the UK retail food market is characterized by close to national pricing.[7]

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 brand advertising in the market. We also control for time effects and seasonality of aggregate potato chip demand. Hence, we are able to exploit within product time series variation in price, conditional on advertising and time effects in aggregate potato chip demand. 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 aggregate time effects, advertising and brand effects deal with the typical sources of endogeneity of prices.

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 brand advertising. Even though we use consumer level data and control for shocks over time to aggregate potato chip demand, there may remain some concern that the individual taste shocks (ϵ_{ibst}) are

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

correlated with advertising. Our advertising state vector $\mathbf{a_{bt}}$ depends on the advertising flow e_{bt} in addition to past advertising flows e_{bt-1}, e_{bt-2}, ... Therefore, if the the state variable $\mathbf{a_{bt}}$ is correlated with demand shocks it is most likely to be through its dependence on the contemporaneous advertising flow. To address this we implement a control function approach (see Blundell and Powell (2004) and for multinomial discrete choice models Petrin and Train (2010)). We estimate a first stage regression of product level monthly advertising flows on time effects and exogenous brand characteristics (included in the demand model), and instruments chosen to be correlated with potato chip brand advertising flows but not with demand shocks. A natural instrument would be the price of advertising, unfortunately we do not directly observe advertising prices. Instead we use advertising expenditure in another market (the ready-meal sector), where shocks to demand are likely to be uncorrelated with shocks in the potato chips market. We interact the instrument with potato chip brand fixed effects. The logic is that ready-meal advertising will be correlated with potato chip advertising through the common influence of the price of advertising but be independent of ϵ_{ibst}. We find that the instrument has power and that the control function is statistically significant in the 'second stage' demand estimation, suggesting that there is some correlation (conditional on other variables in the model) between brand advertising and demand shocks.

We use the model to predict demand in the absence of advertising. A potential concern is whether we are predicting advertising levels outside the range of variation we observe in the data. However, a number of brands in the market, in particular the generic supermarket brands, effectively do not advertise so we observe the advertising state variable at (very close to) zero.

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 a firm 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:

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

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

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

In order for the game to have an equilibrium we must impose restrictions on the functional $\mathcal{A}\left(., ..., .\right)$ 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:

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

which means that the dimension of the state space remains finite, since $\mathbf{a_t} = \mathcal{A}\left(\mathbf{a_{t-1}}, \mathbf{e_t}\right) = \delta \mathbf{a_{t-1}} + \mathbf{e_t}$. 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 $\left\{p_{bst}\right\}_{(b,s)\in F_j}, \left\{e_{bt}\right\}_{b\in B_j}$, which consist of choosing prices and advertising expenditures for the firm's own products and brands ($\sigma_j\left(\mathbf{a_{t-1}}, \theta_t\right) = \left(\left\{p_{bst}\right\}_{(b,s)\in F_j}, \left\{e_{bt}\right\}_{b\in B_j}\right)$).

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, $\pi_j^*\left(.,.\right)$, that satisfies the following Bellman equation

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

where

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

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 $\left(\mathbf{a_{t-1}}, \theta_t\right)$.

We show in the Appendix that, for a given continuous Markov competitor strategy profile σ_{-j}, 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, we just needs to check technical conditions for this recursive equation to define a contraction mapping to guarantee existence of a fixed point, and 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:

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

where $\pi_j^*\left(\mathbf{a_t},\theta_{t+1}\right)$ is the next period discounted profit of firm j, given the vector of future advertising states $\mathbf{a_t}=\left(a_{1t},..,a_{Bt}\right)$. 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 are differentiable in price and have a single maximum, we can use the first-order conditions of firm j profit with respect to prices for each $(b,s)\in F_j$:

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

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 of the profit function 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 $(\mathbf{p_t},\mathbf{e_t})$. 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 consider the impact of a proposed ban on advertising. A new price equilibrium will then be played. We consider Markov equilibria where firms' strategies consist of choosing only 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)). 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).

4 Application

4.1 Data

We apply our model to the UK market for potato chips (called "crisps" in the UK). This is an important source of junk calories. In the US the potato chips market was worth \$9 billion in 2013, and 86% of people consumed some potato chips. The UK potato chips market had an annual revenue of more £2.8 billion in 2013 with 84% of consumers buying some potato chips.[8]

We also believe that this market shares several important characteristics with other junk food markets, which make our results of broader interest. There are a small number of large firms that sell multiple brands and have large advertising budgets. Advertising is mainly in the form of celebrity endorsement or other types that contain little factual information on the characteristics of the product.

We use two sources of data - transaction level purchase data from the market research firm Kantar, and advertising data from AC Nielsen.

[8] 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/.

4.1.1 Purchase data

The purchase data are from the Kantar World Panel for the period June 2009 to October 2010. Our data are unusual in that we have information on households' purchases for food at home *and* individuals' purchases for food on-the-go. 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.

Transactions

We use information on 261,149 transactions over the period June 2009 to October 2010; this includes 161,513 food at home purchase occasions and 99,636 food on-the-go purchase occasions, made by 2872 households and 2306 individuals.

We define a purchase occasion 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. 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).

Products

We define a potato chip product as a brand-pack size combination.[9] Potato chips for consumption at home are almost entirely purchased in large supermarkets as part of the households' main weekly shop, 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

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

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. We use these market prices in demand estimation.

Table 4.1: *Quantity Share and mean price*

Segment:	**Food at home**		**Food on-the-go**	
	Quantity Share	Price (£)	Quantity Share	Price (£)
Walkers	45.66%		54.37%	
Walkers Reg:34.5g			27.16%	0.45
Walkers Reg:50g			7.19%	0.63
Walkers Regular:150-300g	1.77%	1.25		
Walkers Regular:300g+	23.98%	2.77		
Walkers Sensations:40g			2.04%	0.61
Walkers Sensations:150-300g	0.43%	1.26		
Walkers Sensations:300g+	1.81%	2.52		
Walkers Doritos:40g			4.70%	0.54
Walkers Doritos:150-300g	1.30%	1.21		
Walkers Doritos:300g+	3.29%	2.47		
Walkers Other:<30g			4.34%	0.45
Walkers Other:30g+			8.94%	0.61
Walkers Other:<150g	0.69%	1.24		
Walkers Other:150-300g	3.73%	1.77		
Walkers Other:300g+	8.66%	3.17		
Pringles	6.88%			
Pringles:150-300g	1.34%	1.10		
Pringles:300g+	5.54%	2.63		
KP	19.50%		3.87%	
KP:50g			3.87%	0.57
KP:<150g	0.21%	0.85		
KP:150-300g	4.80%	1.19		
KP:300g+	14.49%	2.39		
Golden Wonder	1.50%		4.17%	
Golden Wonder:<40g			3.08%	0.39
Golden Wonder:40-100g			1.09%	0.73
Golden Wonder:<150g	0.10%	1.28		
Golden Wonder:150-300g	0.25%	1.35		
Golden Wonder:300g+	1.15%	2.70		
Asda	3.33%			
Asda:<150g	0.08%	0.93		
Asda:150-300g	0.90%	0.95		
Asda:300g+	2.35%	2.29		
Tesco	6.49%			
Tesco:<150g	0.18%	0.82		
Tesco:150-300g	1.78%	0.91		
Tesco:300g+	4.50%	2.07		
Other	16.66%		37.58%	
Other:<40g			17.57%	0.48
Other:40-100g			20.01%	0.59
Other:<150g	0.94%	1.05		
Other:150-300g	3.94%	1.31		
Other:300g+	11.78%	2.57		

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.

Nutrients Characteristics

We are particularly interested in the nutrient characteristic of the products. Table 4.2 shows the main nutrients in potato chips. We could include these directly in the demand model; for parsimony use an index that combines these into a single score and is used by UK government agencies. It is based on the nutrient profile model developed by Rayner et al. (2005) (see also Rayner et al. (2009) and Arambepola et al. (2008)) and is used by the UK Food Standard Agency, and by the UK advertising regulator Ofcom to determine the healthiness of a product. 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 per 100g reduces the score by 1 point. The UK Food Standard Agency uses a threshold of 4 points or more to define 'less healthy' products, and Ofcom has indicated this is the relevant threshold for advertising restrictions (Ofcom (2007)).

Table 4.2 also shows the nutrient profile score. 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.

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)
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
Pringles	16	2160	6.31	0.62	2.75	4.03
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.

Demographics

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.

We allow all coefficients, including the distribution of the random 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 of household, based on socio-economic status, and (iii) per household member income.

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.

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. Walkers spends the most on advertising. The most advertised brand is Walkers Regular, with on average £500,000 expenditure per month. Walkers Regular also has the highest market share. The table shows the minimum and maximum advertising expenditures by month over June 2009 - October 2010. Advertising expenditures vary a lot across brands, but also across months within a brand. All brands have some periods of zero advertising expenditure, and some brands effectively never advertise, meaning that for these brands the stock of advertising is always very low.

Table 4.4: *Advertising Expenditures*

	Monthly expenditure (£100,000)			Total
	Mean	Min	Max	(06/09-10/10)
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
Pringles	4.50	0.00	10.14	76.54
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 consists mainly of celebrities endorsing brands. The typical adverts show a sports star or a model eating potato chips. Prominent 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. Our interpretation is that these adverts act to persuade and distort consumers' choices in these ways described by Marshall (1921), Braithwaite (1928), Robinson (1933), Kaldor (1950), Dixit and Norman (1978), Gabaix and Laibson (2006), Bernheim and Rangel (2009) and Glaeser and Ujhelyi (2010). This does not affect how we estimate demand, but it does have a fundamental impact on the way that we measure welfare, as described in Section 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 by whether the purchase occasion is for consumption 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 include in the model time effects interacted with the outside option to capture shocks to aggregate demand for potato chips and we include a control function to control for the possible endogeneity of brand advertising (see Section 2.4). Our first stage estimates of the control function suggest that the instrument has power (the F-stat of the joint significance of the instrument-brand effects interactions is 4.0 in the food in segment and 2.3 for the food on-the-go segment). There is some evidence of correlation between brand advertising and demand shocks, particularly in the food at home segment. For 8 of the 11 demographic household groups, we find the control function to be statistically significant at the 95% level. In the food on-the-go segment, the control function is only statistically significant in 1 case. Including the time effects and control function in estimation leads to a reduction in the estimated impact of advertising on demand.

We report the full set of estimated coefficients, along with market own and cross price elasticities and marginal cost estimates in an Appendix. Here we focus on what the estimates imply for how advertising affects consumer demand. We show the impact of advertising on consumers' willingness to pay for the nutrient characteristic, price elasticities and patterns of cross brand and cross pack size substitution.

We compute the willingness to pay for a one point reduction in the nutrient profiling score (which corresponds to an increase in product healthiness), details of this calculation are in the Appendix. 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 6.3 pence per transaction for a one point reduction in the nutrient profiling score for food at home; this falls to 4.6 pence when advertising is at a medium level, and falls further to 1.3 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 3.0% for a 1 point reduction in the nutrient profiling score in the absence of advertising, this falls to 0.6% 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. Table 4.5 makes clear that one thing that advertising does is lower consumers' willingness to pay for an increase in the healthiness of potato chips.

[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 500 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).

Table 4.5: *Effect of advertising on 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	6.3	4.6	1.3
		[5.7, 6.8]	[4.1, 5.0]	[0.3, 2.7]
	% of mean price	3.0	2.2	0.6
		[2.7, 3.3]	[2.0, 2.4]	[0.1, 1.3]
Food on-the-go	Willingness to pay in pence	2.4	1.1	0.0
		[2.1, 2.6]	[1.0, 1.3]	[-0.2, 0.4]
	% of mean price	4.6	2.3	0.1
		[4.2, 5.1]	[1.9, 2.5]	[-0.3, 0.7]

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 at 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 stock of the brand Walkers Regular. 95% confidence intervals are given in square brackets.

In our demand specification we allow advertising to interact with the price coefficient, meaning it can potentially shift consumers' price sensitivities. We find that, for the food at home segment (which represent 86% of the market) advertising leads to a reduction in consumers' sensitivity to price. In order to illustrate the strength of this effect we do the following. For each of the food at home products belonging to three most highly advertised brands, we report, in Table 4.6, the mean market own price elasticity at observed advertising levels and the elasticity if the brand was not advertised in that month (and all other brands advertising had remained at observed levels). Table 4.6 shows that the mean market own price elasticity at observed advertising levels for the 150-300g pack of Walkers is -1.5 and the elasticity for the 300g+ pack size is -2.2. If Walkers unilaterally stopped advertising, demand for its Regular brand, for both the 150-300g pack and the 300g+ pack, would become more elastic; the own price elasticities would be -1.6 and -2.5. A similar pattern is apparent for Pringles and (to a lesser extent) KP.

Table 4.6: *Effect of advertising on own price elasticities*

	Walkers Regular		Pringles		KP	
	Observed advertising expenditure	Zero advertising expenditure	Observed advertising expenditure	Zero advertising expenditure	Observed advertising expenditure	Zero advertising expenditure
¡150g					-1.33	-1.37
					[-1.38, -1.29]	[-1.42, -1.32]
150g-300g	-1.50	-1.63	-1.41	-1.55	-1.69	-1.74
	[-1.57, -1.44]	[-1.69, -1.56]	[-1.47, -1.35]	[-1.61, -1.49]	[-1.75, -1.63]	[-1.80, -1.68]
300g+	-2.20	-2.54	-2.42	-2.79	-2.77	-2.89
	[-2.32, -2.09]	[-2.67, -2.42]	[-2.54, -2.29]	[-2.91, -2.67]	[-2.89, -2.66]	[-3.01, -2.78]

Notes: For each brand in the first row, we report the mean market own price elasticity for each pack size available in the food at home segment. We report the elasticity both at the level of advertising expenditure observed in the data, and if current market brand advertising was unilaterally set to zero. 95% confidence intervals are given in square brackets.

We undertake a similar exercise to illustrate the impact advertising has on brand demand. For each brand in turn, we simulate what market demand would have been in each market (month) if that brand had not been advertised in that month (and all other brands' advertising had remained at observed levels). In Table 4.7 we report the results for the highly advertised brands. If Walkers unilaterally stopped advertising its Regular brand quantity demanded for that brand would fall by 2%; demand for Pringles would increase by 3% (Pringles sales are much smaller than Walkers Regular), while demand for most other brands, and for potato chips overall, would fall. Unilaterally shutting down Pringles' advertising results in a large reduction in the quantity demanded of 15% for that brand, demand for Walkers Regular rises by around 1%, but demand for all other brands falls. The overall effect is to reduce potato chip demand by 1%.

Table 4.7 makes clear that, for a number of brands, advertising is cooperative. The fact that we find evidence of cooperative advertising effects underlines the importance of allowing advertising to enter demand in a flexible way that does not unduly constrain the impact of advertising on demand a priori; if we had only included own brand advertising in the payoff function and omitted the interaction with other characteristics then the functional form assumptions would have ruled out cooperative advertising effects. Notice though, for the largest brand - Walkers Regular - rival advertising is predatory.

Table 4.7: *Effect of advertising on brand demand*

	Walkers Regular	Pringles	KP
Advertising expenditure (£m)	0.497	0.450	0.209
% change in brand demand if advertising expenditure is set to zero			
Walkers Regular	-2.01	1.11	0.47
	[-3.70, -0.69]	[0.79, 1.43]	[0.33, 0.59]
Walkers Sensations	-2.40	-0.64	-0.40
	[-2.77, -1.94]	[-0.96, -0.31]	[-0.52, -0.28]
Walkers Doritos	-1.68	-0.13	-0.35
	[-2.17, -1.13]	[-0.47, 0.19]	[-0.51, -0.21]
Walkers Other	0.54	0.44	0.33
	[0.10, 1.05]	[0.14, 0.75]	[0.19, 0.48]
Pringles	3.07	-15.61	0.25
	[2.41, 3.87]	[-17.63, -13.96]	[0.09, 0.41]
KP	-0.50	-0.16	-2.42
	[-0.93, -0.03]	[-0.53, 0.22]	[-3.31, -1.69]
Golden Wonder	-4.17	-1.17	-1.27
	[-4.62, -3.65]	[-1.56, -0.77]	[-1.46, -1.10]
Asda	-1.54	-0.35	-0.44
	[-1.97, -1.06]	[-0.73, 0.03]	[-0.58, -0.30]
Tesco	-2.54	-1.20	-0.88
	[-2.97, -2.05]	[-1.64, -0.78]	[-1.07, -0.68]
Other	-2.64	-1.37	-1.00
	[-3.05, -2.16]	[-1.76, -0.97]	[-1.18, -0.80]
% change in total potato chips demand if advertising expenditure is set			
	-1.11	-0.98	-0.40
	[-1.44, -0.82]	[-1.29, -0.68]	[-0.53, -0.28]

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.

Table 4.8 shows how setting market advertising to zero for each of the most advertised brands affects demand for each of the pack sizes available for food at home. For each brand it is demand for the largest pack size that declines when advertising expenditure is set to zero; demand for the smaller pack sizes actually increases (although by less than the fall in demand for the larger pack sizes). This highlights that advertising more of a particular brand leads consumers to switch to the larger pack size of the brand.

Table 4.8: *Effect of advertising on demand by pack size*

	Walkers Regular	Pringles	KP
Advertising expenditure (£m)	0.497	0.450	0.209
Change in own brand demand by pack size in 1,000kg if advertising expenditure is set to zero			
<150g			4.98
			[3.89, 5.91]
150g-300g	125.93	2.63	21.44
	[106.58, 141.18]	[-3.98, 7.43]	[13.53, 28.64]
300g+	-284.93	-321.91	-145.48
	[-401.62, -183.35]	[-364.54, -286.58]	[-181.37, -114.07]
Change in own food at home brand demand in 1,000kg if advertising expenditure is set to zero			
	-159.00	-319.28	-119.06
	[-289.83, -48.08]	[-365.52, -280.20]	[-162.67, -83.34]

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.

4.3 Counterfactual Analysis of Advertising Ban

We compare the observed market equilibria with one in which the advertising stocks of all firms are set to zero (i.e. to the situation after advertising has been banned for long enough for the stock to fully depreciate). We find the new equilibrium in all markets (months) and report the means across markets.

4.3.1 Impact on market equilibrium

One effect advertising has on consumer demand is to lower consumers' sensitivity to price (see Table 4.6). Banning advertising therefore leads to toughening price competition. The average price in the market falls by 9%. This fall is driven by price reductions for products in the food at home segment that belong to the most heavily advertised brands. Table 4.9 shows the mean market price in the observed equilibrium with advertising and in the counterfactual equilibrium in which advertising is banned for the food at home products belonging to the three most advertised brands. The ban results in a fall in price for each product in Table 4.9. Walkers reduces the price of its most popular band by the most, reducing the price of the 150-300g pack by 33p (or 26%) and the 300g+ pack by 55p (or 20%). The price of other products available in the food at home segment, belonging to brands that have lower levels of advertising, fall by less, or not at all. Prices in the smaller food on-the-go segment actually increase slightly in response to the advertising ban.

Table 4.9: *Effect of advertising ban on equilibrium prices*

	Walkers Regular		Pringles		KP	
	Observed equilibrium	Advertising banned	Observed equilibrium	Advertising banned	Observed equilibrium	Advertising banned
<150g					0.86	0.75
						[0.74, 0.76]
150g-300g	1.25	0.92	1.11	0.87	1.19	1.07
		[0.90, 0.96]		[0.84, 0.89]		[1.06, 1.08]
300g+	2.79	2.24	2.61	2.20	2.39	2.22
		[2.18, 2.31]		[2.15, 2.24]		[2.21, 2.24]

Notes: Numbers show the mean price across markets in £s. "Observed equilibrium" refers to the prices observed in the data; "Advertising banned" refers to counterfactual prices when advertising is banned. 95% confidence intervals are given in square brackets.

Table 4.10 summarizes the overall impact of an advertising ban on total monthly expenditure on potato chips and the total quantity of potato chips sold.[11] It also shows the impact of the ban on the mean probability a household buys potato chips on a purchase occasion, the average pack size of potato chips purchased, conditional on choosing an inside option, and the average nutrient score of potato chips purchased. The first column shows the average of each variable across markets in the observed equilibria, the second column shows numbers in the counterfactual when advertising is banned but prices are held constant, and the final column shows the numbers for new equilibria when advertising is banned and firms reoptimize prices.

[11] 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 total annual potato chip expenditure in the UK is around £2800m (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 we can compute the implied potential market size and the size of each segment of the market.

Table 4.10: *Effects of advertising ban on purchases*

	Observed	Advertising banned	
	equilibrium	no price response	with price response
Expenditure (£m)	231.1	214.1	220.2
	[227.2, 233.2]	[201.4, 223.7]	[208.2, 229.2]
% change		-7.4	-4.7
		[-12.3, -2.9]	[-9.4, -0.7]
Quantity (m kg)	33.7	30.6	36.5
	[33.1, 34.0]	[28.8, 32.1]	[34.4, 38.1]
% change		-9.3	8.5
		[-14.2, -4.7]	[3.1, 13.2]
Probability of selecting potato chips	0.39	0.37	0.39
	[0.38, 0.39]	[0.35, 0.39]	[0.36, 0.40]
% change		-3.11	0.38
		[-9.71, 2.05]	[-5.72, 4.82]
Mean pack size conditional on purchase (kg)	0.17	0.16	0.18
	[0.17, 0.17]	[0.15, 0.17]	[0.18, 0.19]
% change		-6.41	7.90
		[-10.18, -1.64]	[4.47, 12.49]
Nutrient score	13.6	13.1	12.9
	[13.5, 13.6]	[13.1, 13.2]	[12.8, 13.0]
% change		-3.1	-5.2
		[-3.6, -2.4]	[-5.7, -4.5]

Notes: Percentage changes are shown below variables. "no price response" refers to the situation where advertising is banned and prices are held at their pre ban level; "with price response" refers to the situation where advertising is banned and firms reoptimize their prices. Expenditure refers to total expenditure on potato chip and quantity refers to the total amount of potato chips sold. 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.

In the current equilibria with advertising total monthly expenditure on potato chips was £231m and total quantity sold was 34m kg. The impact of the ban if we hold prices constant is to induce a 7% fall in expenditure and a 9% fall in quantity sold. The reduction in quantity is both down to households buying potato chips less frequently and a fall in the average pack size of potato chip purchases. The average nutrient profiling score of potato chips purchased falls by 3% (meaning consumers switch to products that have a lower - i.e. better - nutrient score). When we account for the fact that oligopolistic firms will respond to the advertising ban by adjusting prices we find that expenditure falls by 5% but total quantity sold actually *increases*. The reason is that firms respond to the advertising ban by lowering prices (on average) and this increases the probability households will select a potato chip product in a purchase occasion. The pattern of price response leads to a larger fall in the nutrient profiling score (of 5%) relative to when prices are held fixed, as consumers switch even more strongly to brands with more healthy nutrient characteristics.

4.3.2 Impact on welfare

In Table 4.11 we summarize the impact of the ban on welfare. In order to calculate compensating variation we need to take a stance on how advertising affects choices and whether it directly enters utility. As discussed in Section 4.1.2, advertising in the UK potato chips market consists largely of celebrity brand endorsements. Our baseline calculation is based on the assumption that this type of advertising does not directly enter utility, and, as outlined in Section 2.2, potentially distorts consumer decision making, leading consumers to make decisions inconsistent with their true underlying preferences.

The first three lines of Table 4.11 show the impact of the ban on consumer welfare. The "choice distortion effect" in the first row is a measure of the welfare gain to consumers of no longer making decisions distorted by advertising. The second row reports the gains through increased price competition. The third row is the sum of these two effects. The "choice distortion effect" leads to a £36 million increase in consumer welfare. The "price competition effect" raises consumer welfare by a further £21 million. Firms, on average, respond to the ban by lowering their prices and consumers benefit from paying these lower prices. In equilibrium, the ban increases total consumer welfare by £57 million per month.

The fourth line shows the impact of the ban on firms' variable profits (net of advertising expenditure). Banning advertising does not lead to a statistically significant change in variable profits. In the Appendix we show profits by firm. The dominant firm, Walkers, plays an important role; it sells more after advertising is banned and this leads to an increase in variable profits (net of advertising expenditure). The profits of other firms fall.

The effect of the ban is to reduce total welfare by £56 million; around one-third of this is due to increased price competition, and around two-thirds to removal of distorting effects of persuasive advertising.

Table 4.11: *Effects of advertising ban on welfare*

	Advertising banned	
	no price response	with price response
Choice distortion effect (£m)	36.2	36.2
	[34.8, 42.0]	[34.8, 42.0]
Price competition effect (£m)	0.0	20.8
		[16.9, 23.8]
Total compensating variation (£m)	36.2	57.0
	[34.8, 42.0]	[54.0, 63.3]
Change in profits (£m)	-0.1	-1.0
	[-6.2, 5.6]	[-6.8, 4.0]
Total change in welfare (£m)	36.1	56.0
	[31.5, 44.6]	[50.3, 64.5]

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. Compensating variation is computed under the view that advertising distorts consumer decision making, as outlined in Section (2.2). 95% confidence intervals are given in square brackets.

We define total welfare as the sum of compensating variation and the change in firms' variable profits. We assume that when advertising is banned consumers take optimal decisions that take into account fully their preferences, including those over long-term health effects from potato chips. If, even under zero advertising, consumers fail to account for possible future costs (or benefits) of potato chip consumption, these will no be included in our welfare calculations. If such effects exist, their importance will depend on to what goods are most substitutable with potato chips. We allow for consumer substitution between potato chips and other products; these will include products that are more nutritious than potato chips - for example, fruit, which has an average nutrient profiling score of -5 - and products that are less nutritious - for example, confectionary, which has an average nutrient profiling score of 25; it is beyond the scope of this paper to estimate differential substitution patterns to other food categories.

An alternative to the view that advertising distorts consumer decision is the view that it enters utility directly as a characteristic that consumers value (Stigler and Becker (1977) and Becker and Murphy (1993)). Under this view advertising is a product characteristic that consumers may place value on, and therefore (holding prices fixed) removing it from the market is likely to reduce consumer welfare. Under this view of advertising in the potato chips market consumer welfare would be comprise a "characteristic effect" and the "price competition effect". As discussed in Section 2.2, the magnitude of the "characteristic effect" is influenced by the normalization of outside option utility. Under our adopted normalization, where own brand and competitor advertising enter the payoff function of inside goods, the "characteristics effect" leads to a reduction in consumer welfare of £33 million, and the overall impact of the ban is then to reduce welfare. This underlines the importance the stance that is taken on how advertising enters utility.

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, reduces consumers' price sensitivities and lowers 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 only if firms do not respond by changing their prices. In the more realistic scenario in which firms re-optimize prices in response to the ban, total demand for potato chips actually rises. This is because the ban increases price competition and so firms respond by lowering average prices and the increase in demand this induces more than offsets the direct fall in demand from no advertising.

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 consist mainly of celebrity endorsements. As our baseline welfare assumption we consider advertising to be persuasive, acting to distort consumer decision making, leading them to take decisions that are inconsistent with their underlying preferences. Under this view of advertising the ban acts to raise consumer and total welfare. In the counterfactual equilibrium consumers no longer make distorted decisions and benefit from lower prices, while in aggregate firms do not lose profits.

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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