Consumers' Asymmetric Demand Patterns for Nutrition-Claim Products versus Non-Nutrition-Claim Products: Evidence from UK

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Abstract

This paper aims to integrate food marking research, economic theory and consumer perspective in order to make novel prediction about the effects of nutritional properties in food on consumers' asymmetric demand patterns. Moreover, we attempt to investigate how nutritional benefits conveyed in products affect consumers' demand response by comparing consumers' price sensitivity across nutrition-claim products (CP) and non-nutrition-claim products (NCP). Using consumer home-scan data, the research adopts the Heckman correction approach to control selection bias, finding that consumers' demand sensitivity is asymmetric across four types of products: healthy food with nutrition claims (HCP), healthy food without nutrition claims (HNCP), unhealthy food with nutrition claims (UNC) and unhealthy food without nutrition claims (UNCP). Specifically, consumers exhibit greater sensitivity for price decreases and less sensitivity for price increases across both healthy and unhealthy food groups. Additionally, the research shows that consumers' demand sensitivity is greater for NCP than for CP. Moreover, the findings suggest that nutrition claims move consumers' undesirable demand patterns to a desirable pattern, keeping a range of household characteristics, coupon usage and store types constant. Notable implications of these results are discussed for marketing practitioners, consumers, researchers, and public health professionals.

Keywords

Price change, demand pattern, nutritional benefit, Heckman correction approach

Introduction

Technological changes over the last century have lowered food costs by making agricultural innovation more efficient, and have subsequently generated the unintended outcome of obesity in both developed and developing countries (Lakdawalla *et al.*, 2005). The number of overweight adults has increased by about 50% in the US in the last 35 years and 35.9% adults are now obese (OECD Health Data, 2014). The adult obesity rate is now more than 20% in the UK, New Zealand and Australia (OECD Health Data, 2014). Such epidemic levels of obesity are partially due to the increased consumption of unhealthy food and decreased level of exercise (Lakdawalla *et al.*, 2005). Public policymakers have thus endeavoured to propel consumers towards healthier food choices by designing economic intervention tools (i.e. placing surcharges and subsidies on food products), and regulatory tools (i.e. implementing nutrition labelling regulations) (Hawkes, 2004; Ma *et al.*, 2013). Successful design of both types of tools and understanding their impact on nudging consumers' food consumption behaviour are important to marketing practitioners, and public health professionals.

Combining nutrition labelling and demand pattern studies is important because it enables researchers to consider market factors (e.g. price) when conducting nutrition labelling research, and facilitates their understanding of how nutrition labelling affects consumers' buying behaviour. However, price changes are often excluded from experiments examining causal relationships between nutrition labelling and food intake because they are treated as unconnected with the food ingredients (Andrews *et al.*, 1998; Epstein *et al.*, 2010; Keller *et al.*, 1997; Kiesel *et al.*, 2011; Kozup *et al.*, 2003; Roe *et al.*, 1999). Generally, participants in experimental conditions do not have to pay for the food and, even if they pay, price is rarely included in the analysis (see examples from Wansink and Chandon 2006, 2007a, 2007b).

Moreover, most previous studies of nutrition labelling and food consumption health benefits focus on observing consumption behaviour related to individual products (i.e. mostly unhealthy ones) or on how the presence of nutrition labelling affects total calorie consumption (see examples from Keller et al. 1997; Kozup et al. 2013). However, in the real market place, consumers rarely buy just one product and the existence of nutrition labelling on one product might influence other purchases. Ma et al. (2013) indicated that consumers with type 2 diabetes are more likely to trade-off one type of unhealthy food (i.e. sugar-rich food) with another (i.e. calorie-rich food).

Addressing the identified gaps in the literature, this study integrates nutrition labelling research, demand theory, and consumer research to examine how nutrition claims alter the demand pattern for different types of product (healthy vs. unhealthy). The paper's contribution to the literature is threefold. Firstly, we contribute by integrating price changes (i.e. going up and going down) into a demand model and quantifying their relative impact on the amount of food consumption. We also compare how the effects of price changes on the quantity of food consumption vary across healthy and unhealthy food, revealing an asymmetric demand pattern in both cases. This finding helps resolve the conflict in the literature concerning whether consumers' price sensitivity varies across scenarios when prices rise and fall.

Secondly, as well as consumption quantity, consumers' price sensitivity is often a primary consideration for managers in deciding whether a food nutrition innovation activity should be implemented and whether a nutrition claim should be labelled since both activities require additional investment on top of the normal non-nutrition-claim product lines. Therefore, to understand how nutrition claims affect consumers' price sensitivity, one must compare consumers' price sensitivity across nutrition-claim products (CP) and non-nutrition claim products (NCP). We make a contribution to the literature by examining this matter and highlighting the impact of nutrition claims on the brand equity, measured from "product-market outcomes"[1] (Ailawadi *et al.*, 2003; Keller and Lehmann, 2006).

The remainder of the paper is structured as follows. The next section discusses the conceptual framework and develops a set of empirically testable hypotheses relating to consumers' demand pattern and price changes for CP and NCP. Section 3 discusses the data used, which comprises consumer transaction records, product attribute information, and consumer demographic characteristic information data from the UK Taylor Nelson Sofres (TNS). This is followed by estimating a Heckman model of healthfulness of consumption in Section 4. The paper concludes by discussing the implications for theory and practice.

Theoretical Development and Hypotheses

Desirable and Undesirable Demand Patterns

From the health policymakers' viewpoint, a desirable demand pattern is one that persuades consumers to purchase more healthy food, whilst an undesirable one does the opposite (Talukdar and Lindsey, 2013). To identify a desirable/undesirable demand pattern by observing consumers' demand patterns, one must first clarify how changes in price affect consumers' demand patterns. The main impact of market prices on food consumption is on the quantity of purchases (Parreno-Selva et al, 2014). Moreover, the impact of prices in determining food demand patterns extends beyond what is in classic microeconomic theory - the "law of demand", which has been evidenced in marketing literature (Talukdar and Lindsey, 2013). According to the law of demand, if a product's price elasticity is -1, and this product was priced at $1 per unit and 100 units were sold in May, when the price increased to $1.01 in June, the demand for this product decreased to 99 units. In this example, a one

[1] "Product-market outcomes" is one of the measures evaluating brand equity. Product-market measures refer to the benefit of brand equity that should be ultimately reflected as the ability of the brand to charge a higher price than other brands (Aaker 1996; Ailawadi et al. 2003).

percentage price increase results in a one percentage decrease in quantity purchased; and a one percentage price decrease results in a one percentage increase in quantity purchased. However, a consumer's demand pattern is more complex if his/her demand sensitivity is asymmetric, meaning price elasticity differs between scenarios where price increases and those where price decreases.

In a symmetric demand pattern, the price elasticity of a product remains the same when prices rise and fall, whereas in an asymmetric demand pattern, this varies with the movement in price. Price changes are perceived by consumers in terms of how they differ from consumers' internal reference price (Janiszewski and Lichtenstein, 1999; Winer, 1986, 1988). As Mazumkar et al. (2005) proposed, we use the last purchase price as the consumers' internal reference price to define whether price has changed. The following examples, based on the case illustrated by Talukdar and Lindsey (2013, p124), demonstrate how the quantity of demand varies across asymmetric and symmetric demand patterns. Imagine the price for a healthy and unhealthy food product is $1 each in May, going down to $0.80 in June, and rising to $1 again in July. Imagine the quantity purchased in May is 100 units for each product. If consumers' demand sensitivity is symmetric, for example, -0.8 for a price increase/decrease, then 116 units are demanded in June and 92.8 in July. If consumers' demand sensitivity is asymmetric, for example, a price elasticity of -0.6 for price increase and -1 for price decrease, the unit of demand is 120 in June and 102 in July.

---Take in Figure 2 about here---

The examples in Figure 2 denote three types of demand pattern: Type 1 - price elasticity is symmetric, i.e. when prices rise or fall the same price elasticity is observed; Type 2 - price elasticity is asymmetric, namely, the price elasticity for a price increase is smaller than that for a price decrease. In this pattern, consumers are more sensitive when a price rises, relative to the last purchase. Type 3 - price elasticity is also asymmetric, but in this case, the price elasticity for a price increase is larger than that for a price decrease. In this pattern, consumers are more sensitive to the scenario when prices rise than when they fall relative to the last purchase. All three patterns obey the law of demand in that as price increases the demand decreases. Although the average price elasticity for healthy and unhealthy food products is identical in symmetric and asymmetric scenarios, the quantity of purchases differs considerably across these three circumstances (Talukdar and Lindsey 2013).

In the context of a symmetric demand pattern, the quantity purchased is no different between healthy and unhealthy food products. Hence, symmetric demand patterns are not relevant to the question of whether this type of demand pattern is desirable or not. However, in the context of an asymmetric demand pattern, if a type 3 pattern was found in unhealthy food consumption behaviour, price increases could substantially decrease the consumption of unhealthy food. Moreover, if a type 2 pattern was found in healthy food, price decreases could considerably increase healthy food consumption. Therefore, a type 2 pattern is desirable for healthy foods while a type 3 pattern is desirable for unhealthy foods. Table 1 summarizes the desirable and undesirable demand patterns for healthy and unhealthy foods where the aim is to improve the quantity of healthy food consumption and decrease the quantity of unhealthy food consumption. The varying demand patterns suggest an avenue in which public policymakers can implement economic policy tools such as surcharges and subsidies on food products to encourage healthy food consumption (Seiders and Petty, 2004; Talukdar and Lindsey, 2013; Thorpe, 2009; Wansink and Huckabee, 2005). Identifying consumer demand patterns provides a method to predict the efficiency of these tools.

---Take in Table 1 about here---

Demand Patterns across Healthy and Unhealthy Foods

One stream of price-nutrition research focuses on consumers' responses towards long-term food price changes. Specifically, research suggests that food price increases lead to decreases in the obesity rate (Chou *et al.*, 2004). Based on panel data across 51 US states from 1984-1999, Chou and his co-authors found that the fast-food restaurant price, the price of the food purchased from the supermarket, and the full-service restaurant price have negative and significant effects on the body mass index. Their findings lend support to Lakdawalla and Philipson (2002), who argued that consumers' weight outcomes rise when food prices reduce. Based on individual level consumer data from 1976-1994, they found a reduction in food prices to significantly impact upon body weight across time and populations, and that nearly forty percent of the growth in body weight results from reduced food prices. These findings imply that when prices of both healthy and unhealthy food decrease, consumers are more likely to over-consume unhealthy food.

The preceding arguments are supported by another stream of price-nutrition research which concentrates on examining how short-term food price changes affect consumers' demand across healthy and unhealthy food types. Research based on cross-sectional consumer panel data suggests that lower unhealthy food prices increase the incentive to buy unhealthy foods (Chandon and Wansink, 2012; Chou *et al.*, 2004; Drewnowski and Darmon, 2005; Epstein *et al.*, 2010; Powell, 2009; Thomas *et al.*, 2011).

Moreover, the marketing literature has shown an asymmetric demand pattern in packaged goods such as ground coffee, beef, potato chips, soft drinks, white bread and peanut butter (Ailawadi *et al.*, 2003; Meyer and Johnson, 1995; Talukdar and Lindsey, 2013). Two main reasons explain this demand pattern. First, an asymmetric demand pattern results from the possibility that gains created by purchasing products at a decreased price are valued higher than losses caused by purchasing products at an increased price (Greenleaf, 1995; Han *et al.*, 2001). For example, Han et al. (2001) analysed consumers' transaction utility, finding consumers respond more aggressively to price decreases than price increases. Greenleaf (1995) also found that consumers are more sensitive to price decreases than price increases based on an aggregated analysis of a national brand of peanut butter.

Second, due to consumers' deal proneness, consumers' price sensitivity is larger for prices that decrease than for prices which increase (Chandon *et al.*, 2000). Chandon et al. (2000) observed that consumers can obtain utilitarian and hedonic benefits by responding to price decreases. Naturally, consumers are deal prone in making purchase decisions, mainly motivated by pursuing utilitarian benefits (Babin *et al.*, 1994; Chandon *et al.*, 2000). Utilitarian benefits emerge because price decreases can offer consumers opportunities to maximize their monetary saving (Blattberg and Neslin, 1993), reduce searching/decision costs (Wansink *et al.*, 1998) and allow consumers to afford better products (Holbrook, 1994). Consumers can also enjoy hedonic benefits by purchasing products with decreased price (Darke and Freedman, 1995; Schindler, 1992; Thaler, 1985), because they are rewarded emotionally and feel pleasure by purchasing discounted products (Bagozzi *et al.*, 1992; Holbrook, 1994; Mittal, 1994).

The aforementioned literature thus suggests that consumers respond more aggressively to a price decrease than to a price increase. Hence, we expect to find an asymmetric demand pattern for both healthy and unhealthy foods. Based on the foregoing argument that the consumers' demand pattern is asymmetric, our first hypothesis is:

H1: Consumers' asymmetric demand response sensitivity is greater for a price decrease than that for a price increase, relative to a last purchase, which is desirable for healthy food and undesirable for unhealthy food.

Nutrition Claims and Demand Response Sensitivity

Food manufacturers and marketers use several nutrition labelling techniques: nutrition claims, health claims, and nutrition fact panels to highlight the nutritional benefits of products. To gain a clear understanding of nutrition claims, one must distinguish nutrition claims from other marketing and public policy labelling aspects. A nutrition claim is a claim made on a food label, suggesting or implying that the food has 'particular beneficial nutritional properties' due to the energy and the nutrients it provides/contains or does not contain (European Commission, 2006). Figure 1 indicates some examples of low fat and high fibre claims. Both healthy and unhealthy food[2] can have nutrition claims on their packages. For example, low fat yogurt, and reduced fat crisps. Health claims, different from nutrition claims, are statements on food package labelling suggesting 'a relationship between food and health', such as 'Vitamin D is needed for the normal growth and development of bone in children' (European Commission, 2006). Both nutrition claims and health claims are different from the nutrition fact panel. A nutrition fact panel (also called nutrition information panel) is a table presenting detailed information of all the nutrient content of the food. Instead of highlighting nutrient attributes or health/disease-related features of the food, a nutrition fact panel lists information such as serving size, total content of each nutrient, percentage daily values. This study focuses on nutrition claims only.

Discussion on whether nutrition labelling can improve consumers' healthy consumption has ranged for decades. Some researchers believe that nutrition claims have a direct and significant impact on food choice in terms of improving healthy purchases (Kreuter *et al.*, 1997; Teisl *et al.*, 2001; Teisl and Levy, 1997; Thorndike *et al.*, 2012). Only when recognized food innovation has been applied in products, can a nutrition claim be made

[2] The definitions of healthy and unhealthy foods are given by the FSA (2011) and FDA (2012). See variable measure section.

on food packages (Chandon and Wansink, 2012). Hence, nutrition claims represent a manufacturer's innovation performance. For example, a claim of 'low in fat' can only be used in product packages when the product contains 3 grams or less of fat per 100 grams of solids or 1.5 grams of fat per 100ml for liquids (European Commission 2006). However, some researchers suggest that the direct influence of nutrition claims on levels of health food consumption may be subject to food types, individual differences, brands, how the nutrition claim has been understood, and even geographic regions where studies occur (Kozup *et al.*, 2003; Roefs and Jansen, 2004; Wardle and Solomons, 1994; Werle *et al.*, 2011). In this study, we consider the question of how nutrition claims influence consumers' demand patterns.

According to empirical evidence from nutrition labelling studies on healthy and unhealthy foods, consumers demonstrate better brand valuation and perception of CP than NCP (Kreuter *et al.*, 1997; Roe *et al.*, 1999; Teisl *et al.*, 2001; Teisl and Levy, 1997; Thorndike *et al.*, 2012). For example, experimental findings show that when consumers have more favourable ratings of the healthfulness of a nutrition-claimed product, they have higher purchase intentions towards that product (Andrews *et al.*, 1998; Roe *et al.*, 1999). Hence, the belief that nutrition claims indicate a healthier product, can improve brand evaluation (Kiesel *et al.*, 2011; Kozup *et al.*, 2003; Levy and Stokes, 1987). Moreover, the marketing literature documents that the level of brand evaluation is negatively associated with consumers' demand response sensitivity (Ailawadi *et al.*, 2003; Blattberg and Wisniewski, 1989; Foxall *et al.*, 2013; Sethuraman, 1995; Sivakumar and Raj, 1997), which suggests that consumers are less price sensitive to highly evaluated brands than they are to lower ones.

Given that CP are better evaluated by consumers, CP may exhibit stronger brand equity than their non-nutrition claimed counterparts. According to the marketing literature, existing measures of brand equity can be categorized into three groups - "customer mind-set", "product-market outcomes" and "financial market outcomes" (Ailawadi *et al.*, 2003). The first refers to consumers' psychological evaluations of a brand, their awareness, attitudes, associations, attachments and loyalties (Aaker, 1996; Keller, 1993), and implies that CP attract better brand equity than those without such claims. The latter two ("product-market outcomes" and "financial market outcomes") focus on the net benefit obtained by a firm/retailer from the equity of their brands. Particularly, the second suggests that price premium brands can charge compared to non-branded or weaker branded brands. Associating this with the implications of first brand equity measurement with marketing research indicates that brands evaluated as better have lower price elasticity than those evaluated worse. Hence, we predict that CP have lower price elasticity than their non-nutrition claim counterparts since the former has higher brand evaluation. Consumers should show greater demand response sensitivity to NCP than to their counterparts with nutrition claims across healthy and unhealthy products. Thus:

H2: Consumers' demand response sensitivity is greater for products with no nutrition claims than for CP, with regard to (a) unhealthy food and (b) healthy food.

After investigating demand patterns between CP and non-nutrition claim products, we compare the demand patterns of the former when prices rise and fall. Prior studies indicate that nutrition claims improve consumers' evaluation of products (Nordfält, 2010; Roe *et al.*, 1999; Thorndike *et al.*, 2012) and thus, may mitigate the undesirable demand pattern of unhealthy food. On one hand, nutrition claims highlight nutrient information to persuade consumers to increase their consumption of healthy products (Roe *et al.*, 1999; Thorndike *et al.*, 2012). For example, Roe et al. (1999) noted that respondents consider a product as healthy when it features a nutrition claim, and are more likely to purchase it (they term nutrition claim as "nutrient-content claim"). A supermarket experiment conducted by Kiesel and Villas-Boas (2011) confirms this, finding that “low-calorie” signs increased popcorn sales.

On the other hand, nutrition claims can enhance consumers’ perceived capability to choose healthy foods by reminding them to consider health motives in their decision-making (Graham and Laska, 2012; Neuhouser *et al.*, 1999; Thorndike *et al.*, 2012). Thorndike et al (2012) conducted two experiments in a large hospital cafeteria, finding that nutrition labels indicating the health level of food can increase the consumption of healthy food and decrease the consumption of unhealthy food. This finding mirrors the evidence obtained by Neuhouser et al. (1999) from survey data collected from 1,400_ US consumers, that nutrition labelling can significantly decrease fat intake. Graham and Laska (2012) also found nutrition labelling to be significantly associated with healthy dietary practices as well as intake. Hence, the view that nutrition claims can activate consumers’ considerations about the healthiness of food consumption and stimulate them to consider health motives when they make food consumption decisions, is supported.

The literature clearly enables the prediction that both healthy and unhealthy CP favourably affect demand patterns, shown by consumers exhibiting greater demand response sensitivity for a price decrease than for a price increase for healthy nutrition-claim products, and greater demand response sensitivity for a price increase than for a price decrease for unhealthy nutrition-claim products. The former demand pattern for healthy CP is in line with the desirable demand pattern for entire healthy food predicted (see Hypothesis 1), and the latter demand pattern for unhealthy CP is opposite to the undesirable demand pattern for entire unhealthy food predicted (see Hypothesis 1b). Therefore, nutrition claims will accentuate the desirable demand pattern for healthy food and mitigate the undesirable demand pattern for unhealthy food. As a result we specify Hypothesis 3 as:

H3a: For healthy food with nutrition claims, consumers' demand response sensitivity is greater for a price decrease than for a price increase, compared with the last purchase price, (a desirable demand pattern).

H3b: For unhealthy food with nutrition claims, consumers' demand response sensitivity is greater for a price increase than for a price decrease, compared with the last purchase price, (a desirable demand pattern).

Methods

Data collection and sample

To test the above hypotheses the sample chosen had the following characteristics. Firstly, we focused packed products such as baked beans, cereals, and juices, because non-packaged food is unlikely to include nutrition information. Secondly, we included all brands in the relevant product category in order to consider substitution effects and facilitate comparison of products with and without nutrition claims. Thirdly, the sample was collected from a real marketplace with actual purchase information such as quantity bought, amount paid, and unit price paid, to consider the direct and indirect impact of price on the healthfulness of food choice. Fourthly, store types are closely related to the availability of healthy food or healthier food options, and thus the sample involved convenience, discount, and drug stores as well as grocery stores.

The study used data from Taylor Nelson Sofres (TNS). Four sources were combined in the course of our analysis. Dataset 1 is a transaction dataset collected by TNS from 6,218 UK households across 52 weeks[3] including more than 1.5 million transaction data points. We

[3] 6,218 households remained in the survey for the entire time. Data points from households that participated for less than 52 weeks were dropped from the analysis dataset. Hence, the sample size reduces from 1.9+million to 1.5+million.

chose 7 main types of packaged food to test our hypotheses (bread, biscuits, cereal products, processed and fresh fish, fruit and vegetable juices, milk and dairy products, potato products and other vegetables). Participants recorded their daily grocery purchases on a central computer through an electronic hand-held scanner in their homes. Additionally, they mailed cash register receipts to TNS in order to match the exact price paid to each purchase. Transaction information includes the quantity purchased, unit price, the amount spent in one shopping trip for one product, a product code, a unique numeric panel ID for the consumer and store code. Dataset 2 comes from a survey conducted by TNS documenting the demographic information for participating households that includes[4]: the main shopper's age, social class, and household size. Hence, we are able to use aggregated food transaction data while controlling consumers' individual heterogeneity.

Dataset 3 is a product attribute file listing the product code, brand name, brand type (national/store brand), brand attributes (i.e. additional ingredients to add extra flavour) and nutritional benefits. We used one dummy variable *Healthy* to classify purchased products into healthy and unhealthy categories according to the profile report published by the UK Food Standards Agency (2011) and US Food and Drug Administration (2014). Dataset 4 is a store information file presenting the store code, store name, grocery chain, store type, and product code. To compile our sample, firstly, Dataset 1 and Dataset 2 were merged by using the unique household panel ID numbers in Dataset A. Secondly, Datasets 3 and 4 were merged by using the product codes in Dataset B. Finally, Dataset A was combined with Dataset B by using product codes, resulting in the final dataset for analysis. Table 2 presents key sample descriptive statistics.

[4] Gender is not included in our analysis because (1) at least one of the household primary shoppers is female in more than 83% of our sample; (2) there are families with more than one primary shopper but only one primary shopper's gender is reported by our participating households. Hence, gender in our dataset does not provide the precise information required to conduct a meaningful and reliable analysis.

---Take in Table 2 about here---

Measures

Healthiness of food choices: To evaluate the healthfulness of food choice, firstly we observed whether a household chose to purchase a product from a healthy food category. Each food type is divided into two categories - healthy and unhealthy, based on definitions by the FSA (2011) and FDA (2012). *Healthy* (H) is a dummy variable indicating whether a household chooses a product from a healthy food type in each shopping trip; *Unhealthy* (UH) is a dummy variable indicating whether a household chooses a product from an unhealthy food type in each shopping trip[5]. For example, if a product belongs to a food category that satisfies "low [in] fat ... and contains at least 10% of daily value … for vitamins A, C, calcium, iron, protein or fibre …" (FDA 2012), it is labelled as *healthy=1* in our sample. Unhealthy food is defined as foods that fail to meet these standards. The coding for variable *unhealthy* is thus opposite to variable *healthy*.

Moreover, apart from considering the choice of food type, we consider the quantity of healthy products purchased across all product categories if a household chooses to buy healthy foods. To make the individual transaction data across products commeasurable, we built a quantity index, $Quantity_{Healthy}$, to measure the quantity purchased from a healthy product. According to the methods used by Foxall et al. (2013), this is calculated as *Quantity Ratio=the actual quantity purchased in a food category/the average quantity purchased in a food category*. The purpose of generating a ratio of quantity is to avoid the comparability of different quantity units across different product types. The quantity of unhealthy food purchased, $Quantity_{Unhealthy}$, is calculated the same way.

[5] Both dummy variables are quintessential in the Heckman model (see Table 3).

Nutrition-claim: In our sample, each product is coded as 1 or 0 depending on whether it contains a nutrition-claim. The variable *nutrition claim is* equal to 1 when the product is nutrition-claimed and 0 when not. It is noteworthy that different nutrition labels may affect demand patterns differently. The focus of this study is to investigate the differences between nutrition claim products and non-nutrition-claim products. Hence, we do not specify different types of nutrition claims in our sample.

Price and Price Changes: Price is measured by a price ratio, *Price= Amount spent/Quantity Ratio,* indicating a standard unit price paid for a product in one transaction. *Amount spent* refers to the amount of money spent by a consumer in one shopping trip on one product. *Quantity Ratio* is the same as illustrated previously. We use the quantity ratio as denominator to make the price comparable across different product categories. Therefore, the amount of money spent on one product in each transaction remain unchanged, *Amount spent=Price*Quantity Ratio.*

As illustrated previously, we adopt the Mazumkar et al. (2005) method of using consumers' last purchase price as their internal reference price. Hence, price changes are measured by whether the price paid for product A at time t is different from the price paid for the same product at time $t-1$, which is in line with using the last purchase price to define whether price has changed (Fibich *et al.*, 2005; Greenleaf, 1995; Kalyanaram and Winer, 1995). Hereafter, if $Price_{time\ t} - Price_{time\ t-1} \neq 0$, it indicates the price for this product has been changed since the last time the consumer purchased it. Moreover, we use price movement indicator (PMI) variables to measure three conditions of price movement relating to the current price and last price paid by a household. Following Talukdao and Lindsey (2013), PMI comprises (1) remain the same (PS), (2) price went up (PU), and (3) price went down (PD).

Control variables: We included control variables in our analysis, which comprised demographic variables (social class, age group, and household size), and marketing variables (store category, brand type, and coupon usage). *Social Class* is used to classify consumers into six occupational groups according to the classification used by the National Readership Survey (NRS 2013), from 1—highest to 6—lowest level. Levels 1 to 6 refers to professional occupations, managerial and technical occupations, skilled non-manual occupations, skilled manual occupations, partly-skilled occupations and unskilled occupations, respectively. *Age* is broken down into 9 age bands in this study as 30<, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, and 65+. Household size is included since it has positive influence on quantity of consumption (Pelto *et al.*, 1991; Rachel and Martin, 2009), and is disaggregated into six size bands, i.e. 1, 2, 3, 4, 5 and 6+. A full list of variables included in our analysis is displayed in Table 3.

Store category measures type of products and their abundance in a shopping environment. *Store Type*, a categorical variable, indicates five types of store: grocery supercentres/supermarkets, convenient stores, drug stores, discount stores, and other stores. *Store type* is also a measurement that indicates the availability of healthy food or healthier options in food (Glanz *et al.*, 2007). Moreover, social class and coupon usage are indicators of affordability of healthy food and healthier options in food (Drewnowski and Darmon, 2005). *Brand Type* is a dummy variable with 1 indicating the brand belongs to a national brand and 0 indicating it belongs to a store/non-branded brand. *Coupon* usage refers to whether the consumer used a coupon on each shopping trip, and is measured by a dummy variable. It is noteworthy that coupon usage does not always indicate a price decrease. For example, a consumer purchases product A at price p' at time t and uses a coupon worth 10p, so the price paid is p'-10p; when he/she repurchases product A at time $t+1$, this product is still priced at p', but he/she uses a coupon worth 5p, so the price paid is p'-5p. The Internal

Reference Price for product A for this consumer is thus *p'*-10p, which is 5p more expensive than *p'*-5p paid at time *t+1*. In addition, age is documented to influence consumers' healthy food choices (Verbeke *et al.*, 2009).

Analysis

In modelling demand, we must consider a household's consumption of healthy and unhealthy foods as a whole. There is a two-stage decision involved for each transaction: stage 1 (i) the decision to purchase healthy/unhealthy food[6] and stage 2 (ii) how much to buy. With respect to the econometric modelling of food purchase behaviour (with price changes as explanatory variables), we adopt the Heckman correction approach (1979), which recognizes that households that purchase healthy food do not purchase healthy food only, and that in the modelling, unhealthy food purchases must also be considered. Failure to account for this self-selection element would lead to results that suffer from selection bias.

It is noteworthy that the Heckman correction approach does not separate the healthfulness of food choice into two stages; the two parts of the Heckman model are estimated in a full information maximum likelihood (FIML) approach simultaneously (Heckman, 1979). Moreover, in the two decision stages involved in purchasing, Stage 2 (how much to buy) is the focus of our model since it closely relates to the diagnosis of consumers' demand pattern. Hence, our analysis is concentrated on Models 1b, 2b, 3b and 4b (see Table 3). Prices are endogenous because retailers change these according to demand and consumers change their demand in response to price (Besanko *et al.*, 1998; Chintagunta *et al.*, 2002; Khan and Jain, 2005; Villas-Boas and Zhao, 2005). A method of simultaneous estimation of price first devised by Maddala (1983) is proposed to take into account the endogeneity problem of price[7].

[6] Hence, Step 1 of Heckman model is a selection model that is estimated in logistic regressions.
[7] Simultaneous details for price estimation are available upon request.

Results

We estimated four Heckman models, all taking healthy and unhealthy food choices into account (outline of model in Appendix 1) and take price changes (remained the same, price went up, price went down) into consideration (see variable definitions in Table 3). The first model (Model 1) estimated quantity of healthy food consumption, and the second (Model 2) estimated quantity of unhealthy food consumption. Models 1 and 2 are used to observe consumers' demand respond sensitivity for healthy and unhealthy food when prices increase and decrease, relative to the last purchase. The model parameters are estimated using aggregate data while taking price endogeneity into account. $\mathbf{H_1}$ is tested by β_{22}, β_{23}, β_{42} and β_{43} in Model 1b and 2b, and these four coefficients are expected to be negative; if the absolute value of β_{23} is larger than that of β_{22} and the absolute value of β_{43} is larger than that of β_{42}, it indicates that consumers respond more aggressively to price decreases than to price increases since the last purchase.

---Take in Table 3 about here---

Model 3 estimated quantity of healthy food consumption and Model 4 estimated quantity of unhealthy food consumption, taking account of the moderating effect of nutrition claim on the relationship between price changes and demand. Models 3 and 4 are used to compare consumers' demand response sensitivity across CP and NCP as well as comparing the demand pattern for CP across healthy and unhealthy foods. Models 3 and 4 thus comprise five price change indicators: price of CP and NCP remain the same (PS) as base; price of nutrition-claimed products went up (PNCU); price of nutrition-claimed products went down (PUCD); price of non-nutrition-claimed products went up (PCU); and price of non-nutrition-claimed products went down (PCD). **H_2** is tested by β_{62}, β_{63}, β_{64}, β_{65}, β_{82}, β_{68}, β_{84} and β_{85} in Models 3b and 4b. **H_{3a}** is tested by β_{62} and β_{63} in Model 3b; and **H_{3b}** is tested by β_{82} and β_{83} in Model 4b.

The diagnostic tests shown in the lower part of Table 4, indicate that the Heckman selection procedure is clearly justified. The Wald test of independent equations with $\chi^2(1)$ values ranges from 6,804 to 68,282 for Model 1-4, rejecting the null hypothesis that ρ=0; Parameter ρ is thus significant from zero. Hence, there is a statistically significant effect of selection, which strongly suggests selection bias if the Heckman model is not used.

---Take in Table 4 about here---

Our results (see Table 5) generally uphold the hypotheses as presented in Section 2. The parameter estimates of the coefficients are generally within the expectations concerning their sign and significance level. Coefficients of price elasticity parameters are all negative, suggesting that consumers' demand patterns follow the "law of demand". For healthy food, (results of Model 1b), the coefficient of the indicator for price change since last purchase is negative and significant (β_{22} =-.350, p<.01) when prices increased and negative and significant (β_{23} =-.548, p<.01) when prices decreased. For unhealthy food (Model 2b), the coefficient of the indicator for price change since last purchase is negative and significant (β_{42}=-.177, p<.01) when prices increased and negative and significant (β_{43}=-.337, p<.01) when prices decreased. Moreover, the absolute value of β_{23} is larger than that of β_{22} and the absolute value of β_{43} is larger than that of β_{42} in Models 2b, suggesting that consumers are more sensitive to price decreases than increases. Thus, **H_1** is supported.

---Take in Table 5 about here---

When prices increased, the coefficient of the indicator for price change since last purchase is negative and significant for CP and NCP. For healthy food types, (Model 3b), the price elasticity for NCP (β_{64} =-.645, $p<.01$) is larger than that for CP (β_{62} =-.174, $p<.01$) went the price increased. Hence, consumers respond more aggressively to NCP than nutrition-claimed ones when prices rise. This demand pattern for healthy food also holds true for unhealthy food (β_{84} =-.473, $p<.01$; β_{82} =-.075, $p<.01$) when prices rise (Model 4b). Thus, $\mathbf{H_2}$ is supported when the price increases relative to last purchase.

When prices decreased, the coefficient of the indicator for price change since last purchase was larger for NCP (β_{65} =-.852, $p<.01$) than for CP (β_{63} =-.404, $p<.01$) (Model 3b). Hence, consumers respond more aggressively to non-nutrition-claimed food products than nutrition-claimed ones when prices decrease. This demand pattern for healthy food holds true for unhealthy food (β_{85} =-.875, $p<.01$; β_{83} =-.043, $p<.01$) when prices decrease (Model 4b). Hence, $\mathbf{H_2}$ is also supported when prices decrease, relative to last purchase.

As for the coefficient of the indicators for price change for CP, we found these to be negative and significant across healthy and unhealthy foods. In particular, for healthy food types, the results of Model 3b show that the coefficient of the indicator for price change since last purchase is smaller when price increases (β_{62}=-.174, $p<.01$) than when it decreases (β_{63}=-.404, $p<.01$) for CP. This demand pattern of CP for healthy food is the opposite for unhealthy food. Namely, as seen in Model 4b, the coefficient of the indicator for price changes since last purchase when prices rise (β_{82}=-.075, $p<.01$) is larger than when prices decrease (β_{83}=-.043, $p<.01$) for CP. Thus, $\mathbf{H_{3a}}$ and $\mathbf{H_{3b}}$ are supported.

Although it is not hypothesized, we observed the coefficients of the indicators for price change for NCP were negative and significant in order to compare the demand patterns between NCP and CP. Specifically, for healthy food types, the results of Model 3b show that the coefficient of the indicator for price change since last purchase is smaller when price rises (β_{64}=-.645, p<.01) than when it falls (β_{65}=-.852, p<.01). This demand pattern of NCP holds true for unhealthy food (β_{84}=-.473, p<.01; β_{85}=-.875, p<.01), as seen in Model 4b. Thus, for NCP, consumers' demand response sensitivity is greater for a price decrease than for a price increase, compared with the last purchase price, which is desirable for healthy food and undesirable for unhealthy food.

Discussion and Conclusions

Theoretical Implications

This study integrates microeconomic literature, marketing research and nutrition labelling studies, uses several datasets, and the Heckman correction approach to correct sample selection bias in order to demonstrate a better and novel understanding of consumers' demand patterns for CP and NCP across healthy and unhealthy foods. Several important conclusions emerge from this study. Our results show firstly, that consumers' demand sensitivity varies across scenarios when prices rise and fall, exhibiting demand patterns that are desirable for healthy food consumption and undesirable for unhealthy food consumption. Secondly, CP are found to exhibit a desirable demand pattern of unhealthy food consumption while NCP show an undesirable pattern of unhealthy food consumption, thus indicating that nutrition claims alter the undesirable demand pattern for unhealthy food. The preceding findings lead us to conclude that appreciating the value of price as a marketing tool requires managers to consider whether their price promotion strategies are sufficient to facilitate increased consumption and profit in the long term, and also to appreciate nutrition claims as an important way of improving consumers' healthy consumption when accounting for the price changes.

Our finding that consumers' demand pattern is asymmetric for healthy and unhealthy foods has been underdeveloped in marketing literature, and it shows the danger of assuming that consumers' demand sensitivity is symmetric when prices rise and fall. Such an assumption can lead to misunderstanding about the complexity of price changing effects. Our findings give compelling reasons to recognize the asymmetric demand pattern because price changes, not price by its own, essentially influence consumers' healthy consumption. We found that consumers are more sensitive to price decreases than price increases across food types, which is desirable for healthy food but undesirable for unhealthy food (See Table 1). This evidence indicates that gaining from buying products when their prices fall compared to the last purchase price predominantly determines consumers' demand pattern, which is tenable across healthy and unhealthy foods. The nature of the asymmetric pattern revealed contributes much needed theoretical insights from nutrition labelling study (Chandon and Wansink, 2012) and demand pattern study (Talukdar and Lindsey, 2013).

Our second set of findings highlights how nutrition claims influence consumers' price sensitivity. By comparing consumers' demand response sensitivity across CP and NCP, we show that consumers respond more aggressively to NCP than nutrition-claimed ones for both scenarios when prices rise and fall. Nutrition-claimed products thereby have lower price elasticity than their non-nutrition-claimed counterparts; hence, retailers can charge a premium for CP. According to the "product-market outcomes" (Ailawadi *et al.*, 2003; Keller and Lehmann, 2006), a product with stronger brand equity has the ability to charge a higher price than a weaker brand. Therefore, the finding suggests that nutrition claims can enhance and strengthen products' brand equity since consumers are less likely to decrease their consumption when process rise and more likely to purchase the brand with a price premium. Given that nutrition claims improve consumers' brand valuations and perceptions, and thus strengthen brand equity which is measured from "customer-based sources" (Keller, 1993), our finding contributes to the marketing literature by extending the scope of conceptualization and the research avenues of brand equity.

Debate on whether the policy-relevant variable, nutrition claims improves consumers' healthy consumption had not yet been settled. Our third set of findings offers a novel contribution to studies in marketing and nutrition labelling which have so far failed to accept the fact that nutrition claims are able to alter consumers' demand pattern. Consideration only of whether nutrition claims influence consumers' product choice remains on the periphery of this debate because it does not sufficiently address the comprehensive impacts of nutrition claims. The findings support our prediction that a nutrition claim changes the undesirable demand pattern on unhealthy food into a desirable one, whilst leaving the undesirable demand pattern of unhealthy food without nutritional benefits unchanged. They lend support to the view that nutritional labels function to remind consumers to reconsider health motives, and thus increase their consumption of healthy foods (Graham and Laska, 2012; Neuhouser *et al.*, 1999; Thorndike *et al.*, 2012). Moreover, it highlights the danger of seeking empirical findings based on one or two product categories since the direct impact of nutrition claims on product choice may vary from one product to another. Inconclusive findings may indicate that nutrition claims have insignificant influence on product evaluations or purchase intentions (Garretson and Burton, 2000). The study contributes to the corpus of marketing literature that has sought to unravel the black box of contradictory findings relating to the impact of nutrition claims on the consumption of healthy food through altering undesirable demand patterns when taking prices change into account.

In a broader sense, our research responds to the recent research call to study large-scale consumer transaction data (Griffith and O'Connell, 2009) from non-North American consumers comprised purely of undergraduate students (Chandon and Wansink, 2012). Moreover, our model controls selection bias, treating food price as endogenous (and thus instrumented), which serves to preserve heterogeneity in the data analysis. Furthermore, in order to take account of commentary and substitution effects, we do not limit our observation to a one-time purchase or a single product, but rather base our analysis on a set of products with/without nutrition claims across healthy and unhealthy foods, thereby extending the reliability and generalizability of our findings.

Managerial Implications

From the perspective of public policy-makers, our findings shed new light on the effectiveness of economic intervention tools. Indeed, policies aimed at decreasing the consumption of unhealthy food by increasing prices (e.g. Pigovian taxes) may not be successful. Furthermore, it is unclear how such surcharges are actually reflected in retail prices (e.g. marketers may generate profits by using promotion tools to increase sales instead of increasing the unit price of unhealthy products; see example in Shah et al, 2014) , and the amount of demand for non-nutrition-claimed unhealthy food will decrease less than expected since consumers' demand response is less sensitive to price increase than to price decrease relative to last purchase. Hence, the effects of economic intervention tools towards unhealthy food are very limited towards non-nutrition-claimed unhealthy food, thus demonstrating an undesirable demand pattern.

However, economic interventions such as the Pigovian tax are more efficient in reducing consumption of nutrition-claimed unhealthy food since consumers' response demand is more sensitive when price rises than when it drops. Despite the mixed efficacy of economic intervention tools, surcharges placed on non-nutrition-claimed unhealthy food production and marketing activities will generate more government revenue than expected due to the resistance of the demand pattern. Given the enormous financial drain on a country caused by obesity (Thorpe, 2009), government can use this revenue to prevent and deal with negative externality caused by overconsumption of unhealthy food.

On the other hand, policies designed to increase healthy food consumption by subsidizing (e.g. Pigovian subsidy) healthy food production are likely to be more effective than once thought since they do induce healthy food consumption. Because consumers are more sensitive to price decreases than to price increases in healthy food, lowering prices of healthy food will attract greater demand than expected. Hence, subsidizing healthy food production is effective in increasing healthy food proportions in consumers' baskets, thereby indirectly decreasing unhealthy food consumption. Consumers' demand response sensitivity is reduced by the presence of nutrition claim; hence, the demand for nutrition-claimed healthy food will not increase as much as expected. Therefore, economic subsidizing tools are less effective for nutrition-claimed healthy food than for non-nutrition-claimed healthy food.

Our findings support the view that nutrition claims are important in promoting healthy food consumption, because they can mitigate undesirable demand patterns. Given the moderating role that nutrition claims play in altering such undesirable demand pattern, strict scrutiny of nutrition labelling regulations is imperative to ensure that reliable and easy-to-understand nutrient information is highlighted and wisely used in consumer decision-making. Abuse of nutrition labelling may bring severe consequences such as increasing obesity as consumers become more resistant to nutrition-claimed food than non-nutrition-claimed food.

These policy implications reveal that the effectiveness of economic intervention tools depends not only on the type of food (unhealthy vs. healthy) but also on the type of product (nutrition-claimed vs. non-nutrition-claimed). This differs from findings obtained from studies that have not considered the moderating effect of nutrition claims, and wrongly concluded that economic interventions are limited in persuading consumers to reduce unhealthy food consumption (Talukdar and Lindsey, 2013). However, in line with previous research, this study confirms that policy implications can be more accurate when a whole basket of goods rather than individual products/single purchase occasion, is examined

(Drewnowski and Darmon, 2005; Ma *et al.*, 2013; Schroeter *et al.*, 2008), since substitute relationships among unhealthy food or across healthy and unhealthy food were controlled in this study, and it is clear that policy suggestions founded on taxing a single product bring unintended consequences by consumers substituting one unhealthy product by another (Lakdawalla *et al.*, 2005).

From the perspective of marketing practitioners, these findings reveal the value of investing in food innovations in terms of producing more nutritional tasty food. Consumers' demand response is less sensitive for nutrition-claimed food than for non-nutrition-claimed food. Hence, nutrition-claimed food has greater potential for food marketers to extract consumer surplus than expected. For unhealthy food manufacturers, developing healthier options in their existing product line is not only profitable but also strategically important to strengthen the brand reputation by valuing consumers' welfare. Innovation expenditure can be invested in increasing food's satiating power and maintaining the level of palatability without increasing the amount of fat, sugar and salt in a food.

For healthy food manufacturers, it is important to develop healthier options in existing product lines and food innovation can be focused on developing palatability to counteract consumers' negative sensory perceptions about healthy food. It is also noteworthy that marketing practitioners may find that the efficacy of marketing activities such as price discounts is substantial not only temporarily, but also in the long term due to its impact on the asymmetric demand pattern. For example, we found that the demand pattern is asymmetric (consumers' price sensitivity is higher when prices drop and lower when they rise) for healthy food; therefore, even if the post-sale demand is lower than the demand during the sale, the post-sale demand is still higher than initial demand, as seen in Figure 2.

Limitations and Directions for Future Research

Some limitations of this study point the way to additional research. Firstly, the empirical analysis focused on the UK FMCGs industry and an investigation across different industries, other geographic regions or different cultural settings would be interesting to establish whether variations exist. Additionally, the findings could be compared with both developed countries (e.g. France, US) and developing countries with epidemic levels of obesity (e.g. Chile, Mexico), thus establishing whether the impacts of nutrition claim toward consumer demand patterns are constant in these different contexts.

Secondly, the study focuses on the asymmetric patterns across CP and NCP, whereas the ‘healthy’ claim is not considered due to sample limitation. Given that nutrition and health claims are considered to be strong marketing incentives for the packaged food industry (Williams and Ghosh, 2008), the co-presence of nutrition and health claims may have an impact on consumers’ demand patterns, and future studies could explore whether differences occur among consumers’ demand patterns towards CP only, and those with both nutrition and health claims. Moreover, it would be worthwhile to investigate the interaction effects of health claims in terms of mitigating or accentuating consumers’ demand patterns across healthy and unhealthy foods.

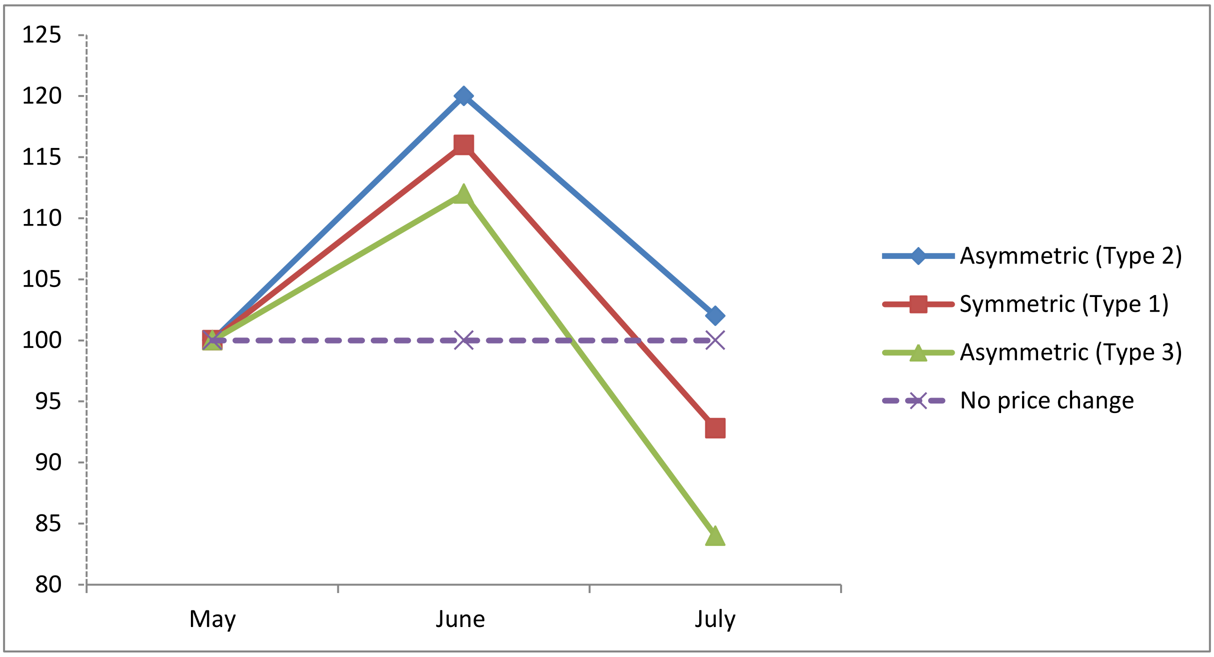
Thirdly, we do not consider the moderating effects of different types of nutrition claims on the demand patterns across healthy and unhealthy foods. Different nutrition labels may have different effects on demand patterns. This study does not address the individual differences across nutrition claims. Nor does it account for the dual presence of nutrition claims (e.g. both reduced sugar and high in fibre presented in some cereal products). Products with more than one type of nutrition claim may have stronger impact on consumers’ demand pattern. Further studies can examine variations in the strength of moderating effects across different nutrition claims, and whether consumers' response sensitivities vary across products with the dual-presence of nutrition claims and those with a single nutrition claim.

Fourthly, further research could be conducted to examine how the asymmetric price effects on demand may differ across different brand names (e.g. domestic vs foreign brands), brand types (e.g. national brands vs store brands) and/or store types (e.g. convenience store vs large supermarkets).

Figures

Figure 1. Examples of nutrition claims conveyed in food packages

Figure 2. Examples of demand patterns



Tables

Table 1. Desirable and undesirable demand patterns for healthy and unhealthy food

Demand Pattern	Healthy Food	Unhealthy Food
Desirable	Consumers are more sensitive for price went down than price went up	Consumers are more sensitive for price went up than price went down
Undesirable	Consumers are more sensitive for price went up than price went down	Consumers are more sensitive for price went down than price went up

Table 2. Descriptive Statistics

Variable	Category	Frequency	Percentage	Variable	Category	Frequency	Percentage
Healthy Food	No	879,394	57.26	**Store Types**	Other	3,817	0.25
	Yes	656,383	42.74		Convenient	42,911	2.79
					Discount	137,265	8.94
Nutrition Claim	No	903,824	58.85		Grocery	1,350,299	87.92
	Yes	631,953	41.15		Drug store	1,485	0.1
Coupon Usage	No	1,268,909	82.62	**Socio Class**	1	10,008	0.65
	Yes	266,868	17.38		2	168,107	10.95
					3	470,233	30.62
Age Band	30<	52,700	3.43		4	422,461	27.51
	30-34	135,923	8.85		5	248,762	16.2
	35-39	190,632	12.41		6	216,206	14.08
	40-44	178,595	11.63				
	45-49	180,398	11.75	**Household Size Band**	1	174,647	11.37
	50-54	179,024	11.66		2	529,490	34.48
	55-59	206,614	13.45		3	257,211	16.75
	60-64	155,110	10.1		4	387,921	25.26
	65+	256,781	16.72		5	133,007	8.66
					6+	53,501	3.48
Total		1,535,777	100.00	Total		1,535,777	100.00

Table 3. Regression models and variable definitions

Heckman Model Specification

Model 1 stage 1: $H=\beta_{10}+\beta_{11}\ln(P_{ij})+\beta_{12}NC_{ij}+\beta_{13}CU_{ij}+\beta_{14}BT_{ij}+\beta_{15}ST_{ij}+\beta_{16}SC_{ij}+\beta_{17}AR_{ij}+\nu_i$ (M1a)

Model 1 stage 2: $\ln(QH)=\beta_{20}+(\beta_{21}PS_{ij}+\beta_{22}PU_{ij}+\beta_{23}PD_{ij})\ln(P_{ij})+\beta_{24}NC_{ij}+\beta_{25}CU_{ij}+\beta_{26}BT_{ij}+\beta_{27}ST_{ij}+\beta_{28}SC_{ij}+\beta_{29}AR_{ij}+\beta_{210}HS_{ij}+\mu_i$ (M1b)

Model 2 stage 1: $UH=\beta_{30}+\beta_{31}\ln(P_{ij})+\beta_{32}NC_{ij}+\beta_{33}CU_{ij}+\beta_{34}BT_{ij}+\beta_{35}ST_{ij}+\beta_{36}SC_{ij}+\beta_{37}AR_{ij}+\nu_i$ (M2a)

Model 2 stage 2: $\ln(QUH)=\beta_{40}+(\beta_{41}PS_{ij}+\beta_{42}PU_{ij}+\beta_{43}PD_{ij})\ln(P_{ij})+\beta_{44}NC_{ij}+\beta_{45}CU_{ij}+\beta_{46}BT_{ij}+\beta_{47}ST_{ij}+\beta_{48}SC_{ij}+\beta_{49}AR_{ij}+\beta_{410}HS_{ij}+\mu_i$ (M2b)

Model 3 stage 1: $H=\beta_{50}+\beta_{51}\ln(P_{ij})+\beta_{52}NC_{ij}+\beta_{53}CU_{ij}+\beta_{54}BT_{ij}+\beta_{55}ST_{ij}+\beta_{56}SC_{ij}+\beta_{57}AR_{ij}+\nu_i$ (M3a)

Model 3 stage 2: $\ln(QH)=\beta_{60}+(\beta_{61}PS_{ij}+\beta_{62}NCU_{ij}+\beta_{63}PNCD_{ij}+\beta_{64}PCU_{ij}+\beta_{65}PCD_{ij})\ln(P_{ij})+\beta_{66}NC_{ij}+\beta_{67}CU_{ij}+\beta_{68}BT_{ij}+\beta_{69}ST_{ij}+\beta_{610}SC_{ij}+\beta_{611}AR_{ij}+\beta_{612}HS_{ij}+\mu_i$ (M3b)

Model 4 stage 1: $UH=\beta_{70}+\beta_{71}\ln(P_{ij})+\beta_{72}NC_{ij}+\beta_{73}CU_{ij}+\beta_{74}BT_{ij}+\beta_{75}ST_{ij}+\beta_{76}SC_{ij}+\beta_{77}AR_{ij}+\nu_i$ (M4a)

Model 4 stage 2: $\ln(QUH)=\beta_{80}+(\beta_{81}PS_{ij}+\beta_{82}PNCU_{ij}+\beta_{83}PNCD_{ij}+\beta_{84}PCU_{ij}+\beta_{85}PCD_{ij})\ln(P_{ij})+\beta_{86}NC_{ij}+\beta_{87}CU_{ij}+\beta_{88}BT_{ij}+\beta_{89}ST_{ij}+\beta_{810}SC_{ij}+\beta_{811}AR_{ij}+\beta_{812}HS_{ij}+\mu_i$ (M4b)

	Variable	Definitions	Source
Healthfulness of food purchased	*H*	Healthy –A dummy variable equals to 1 when consumers choose product belongs to healthy food type	Dataset 3
	UH	Unhealthy –A dummy variable equals to 1 when consumers choose product belongs to unhealthy food type	Dataset 3
Quantity of demand	*QH*	$\text{Quantity}_{\text{Healthy}}$—On the condition that a household chose to purchase a healthy food, an index indicating quantity of healthy food purchased in each shopping trip	Dataset 3
	QUH	$\text{Quantity}_{\text{Unhealthy}}$—On the condition that a household chose to purchase a unhealthy food, an index indicating quantity of healthy food purchased in each shopping trip	Dataset 3
Price	*P*	Price paid in a standardized unit for one product on each shopping occasion of one household	Dataset 1
	PS	Price remains the same	Dataset 1
	PU	Price of products went up since last purchase	Dataset 1

Price Movement Indicators	*PD*	Price of products went down since last purchase	Dataset 1
	PNCU	Price of nutrition claimed-products went up since last purchase	Dataset 1
	PNCD	Price of nutrition claimed-products went down since last purchase	Dataset 1
	PCU	Price of non-nutrition claimed-products went up since last purchase	Dataset 1
	PCD	Price of non-nutrition claimed-products went up since last purchase	Dataset 1
Control Variables			
	NC	Nutrition claim—One dummy variable equals to 1 when a nutrition claim presents	Dataset 3
Product-related characteristics	*CU*	Coupon usage—One dummy variable equals to 1 when a coupon has been used	Dataset 1
	BT	Brand types—One dummy variable equals to 1 when a brand is a national brand, which equals to 0 when a brand is a store or none branded brand	
Store-related characteristics	*ST*	Store types—Four dummy variables indicate store types: Convenient=1 if a product is purchased from a convenient store, e.g. "Tesco Express". Discount=1 if a product is purchased from a discount store, e.g. "Lidl". Grocery=1 if a product is purchased from a supercenter that primarily sell food, e.g. "Tesco Extra". Drug stores=1 if a product is purchased from a retail store featuring a pharmacy and selling grocery items, e.g. "Boots". Other stores=1 if a product is purchased from none of the above stores	Dataset 4
Consumer-related characteristics	*SC*	Social Class –A classification measured from the occupancy of a household, broken down to six social economic statuses: from 1—highest to 6—lowest level.	Dataset 2
	AR	Age range—Age of the shoppers, broken down into nine age bands, i.e. 30<, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, and 65+.	Dataset 2
	HS	Household size—Number of people living in a household, broken down to six size bands, i.e. 1, 2, 3, 4, 5 and 6+.	Dataset 2
	m_i	m_i is an error term for stage 2 of Heckman model.	
	n_i	n_i is an error term for stage 1—selection equation of Heckman model.	
	$\beta_1 \ldots \beta_{13}$	Model Coefficients, where β_1 estimates consumers' base level of own price elasticity when price remains the same since last purchase; β_2, β_3 estimates how the base level of price elasticity is affected by the price movement direction since last purchase; β_{10}, β_{11}, β_{12}, β_{13} estimates how the base level price elasticity is affected by the price movement direction and by its interaction with the presence of nutrition claims	

Table 4. Heckman (Stage 1) probit models for healthfulness of food choice†

Dependent variable: choosing healthy food or not

Independent Variables	**Model 1a Healthy** $\partial\hat{p}/\partial x$	**z-value**	**Model 2a Unhealthy** $\partial\hat{p}/\partial x$	**z-value**	**Model 3a Healthy** $\partial\hat{p}/\partial x$	**z-value**	**Model 4a Unhealthy** $\partial\hat{p}/\partial x$	**z-value**
ln(Price)	-0.118***	(-187.37)	0.137***	(204.27)	-0.129***	(-209.66)	0.125***	(194.12)
CU (coupon usage)	-0.019***	(-17.93)	0.054***	(52.63)	-0.022***	(-20.72)	0.041***	(40.02)
NC (nutrition claim)	0.072***	(88.48)	-0.034***	(-43.69)	0.077***	(95.22)	-0.047***	(-60.24)
Brand type	-0.069***	(-80.20)	0.047***	(55.57)	-0.062***	(-72.81)	0.061***	(71.97)
Store type (other store as base)								
Store type (convenient store)	0.083***	(10.29)	-0.096***	(-12.57)	0.081***	(10.15)	-0.094***	(-12.13)
Store type (discount store)	0.014*	(1.85)	-0.035***	(-4.69)	0.016**	(2.06)	-0.029***	(-3.89)
Store type (grocery store)	0.075***	(9.74)	-0.091***	(-12.53)	0.078***	(10.24)	-0.088***	(-11.76)
Store type (drug store)	-0.246***	(-21.07)	0.215***	(18.05)	-0.242***	(-20.73)	0.251***	(22.97)
Social Class 1 (as base)								
Social Class 2	-0.007	(-1.48)	0.011**	(2.16)	-0.008*	(-1.68)	0.009***	(1.88)
Social Class 3	-0.035***	(-7.15)	0.037***	(7.70)	-0.037***	(-7.49)	0.037***	(7.63)
Social Class 4	-0.073***	(-14.81)	0.074***	(15.55)	-0.075***	(-15.36)	0.074***	(15.26)
Social Class 5	-0.080***	(-16.10)	0.083***	(17.16)	-0.083***	(-16.79)	0.082***	(16.83)
Social Class 6	-0.068***	(-13.57)	0.070***	(14.35)	-0.071***	(-14.22)	0.070***	(14.12)
Age band 1 (as base)								
Age band 2	-0.017***	(-6.79)	0.021***	(8.73)	-0.018***	(-7.36)	0.019***	(7.98)
Age band 3	-0.028***	(-11.80)	0.028***	(12.43)	-0.029***	(-12.17)	0.029***	(12.61)
Age band 4	-0.015***	(-6.34)	0.021***	(9.12)	-0.017***	(-7.08)	0.018***	(7.78)
Age band 5	-0.005**	(-2.30)	0.012***	(5.30)	-0.007***	(-2.93)	0.009***	(3.81)
Age band 6	0.022***	(9.27)	-0.013***	(-5.43)	0.021***	(8.85)	-0.016***	(-6.90)
Age band 7	0.038***	(16.19)	-0.029***	(-12.54)	0.037***	(15.93)	-0.032***	(-13.90)
Age band 8	0.041***	(16.77)	-0.031***	(-13.02)	0.041***	(16.71)	-0.034***	(-14.22)

Age band 9	0.077***	(32.89)	-0.064	(-28.23)	0.077***	(32.74)	-0.068***	(-29.30)
ρ	-0.493***		0.906***		-0.675***		0.850***	
σ	0.370***		0.374***		0.377***		0.325***	
λ	-0.181***		0.339***		-0.255***		0.277***	
(Unweighted) N	1,535,777		1,535,777		1,535,777		1,535,777	
N(Healthy=1)	656,383				656,383			
N(Unhealthy=1)			879,394				879,394	
Log pseudo-likelihood	-1230436		-1089334		-1183529		-1021579	
Wald test of independent equations: $x^2(1)$	6804.09		68282.09		13769.85		36885.78	

†Average marginal coefficients are reported.

* p<0.05 ** p<0.01 *** p<0.001

Table 5. Heckman (Stage 2) regression analysis results for quantity purchased

Dependent variable: quantity of demand

	Coefficient Estimate (z-value)							
	Model 1b		**Model 2b**		**Model 3b**		**Model 4b**	
Independent Variables	**ln(QH)**		**ln(QUH)**		**ln(QH)**		**ln(QUH)**	
Price remained same (as base)	—		—		—		—	
Price went up	-0.350***	(-372.05)	-0.177***	(-269.47)				
Price went down	-0.548***	(-216.64)	-0.337***	(-127.24)				
Price went up for nutrition-claimed products					-0.174***	(-167.34)	-0.075***	(-111.34)
Price went down nutrition-claimed products					-0.404***	(-152.84)	-0.043***	(-17.21)
Price went up for non-nutrition-claimed products					-0.645***	(-484.87)	-0.473***	(-440.52)
Price went down for non-nutrition-claimed products					-0.852***	(-180.63)	-0.875***	(-257.34)
Control Variables								
Coupon usage	0.098***	(80.93)	0.083***	(89.32)	0.073***	(61.36)	0.072***	(87.22)
Nutrition claim	-0.066***	(-73.09)	0.039***	(52.26)	-0.113***	(-125.13)	-0.019***	(-27.73)
Brand type	0.035***	(35.07)	0.014***	(19.82)	0.058***	(60.32)	0.018***	(27.42)
Store type –other store (as base)	—		—		—		—	
Store type –convenient store	-0.098***	(-9.61)	-0.100***	(-14.27)	-0.085***	(-8.59)	-0.110***	(-17.72)
Store type –discount store	-0.089***	(-8.95)	-0.059***	(-8.66)	-0.079***	(-8.09)	-0.066***	(-10.91)
Store type –grocery store	-0.002	(-0.21)	-0.027***	(-4.09)	0.016	(1.68)	-0.019**	(-3.16)
Store type –drug store	0.340***	(10.41)	0.105***	(8.79)	0.475***	(15.46)	0.118***	(11.29)
Social Class 1 (as base)	—		—		—		—	
Social Class 2	-0.053***	(-10.11)	-0.026***	(-5.57)	-0.058***	(-11.12)	-0.032***	(-7.83)
Social Class 3	-0.056***	(-10.73)	-0.024***	(-5.42)	-0.057***	(-11.16)	-0.036***	(-9.10)
Social Class 4	-0.068***	(-13.06)	-0.013**	(-2.83)	-0.066***	(-12.85)	-0.033***	(-8.11)
Social Class 5	-0.074***	(-14.03)	-0.022***	(-4.82)	-0.073***	(-14.04)	-0.043***	(-10.76)

Social Class 6	-0.086***	(-16.22)	-0.036***	(-7.78)	-0.091***	(-17.45)	-0.060***	(-14.83)
Age band 1 (as base)	—		—		—		—	
Age band 2	-0.003	(-0.93)	0.013***	(6.05)	-0.008**	(-2.94)	0.008***	(4.21)
Age band 3	0.019***	(7.03)	0.029***	(13.69)	0.020***	(7.36)	0.025***	(13.53)
Age band 4	0.009***	(3.29)	0.024***	(11.15)	0.001	(0.50)	0.015***	(7.94)
Age band 5	0.001	(0.32)	0.013***	(6.22)	-0.010***	(-3.85)	0.001	(0.65)
Age band 6	-0.014***	(-5.00)	0.003	(1.53)	-0.027***	(-10.19)	-0.005**	(-2.71)
Age band 7	0.005*	(1.97)	-0.005**	(-2.59)	-0.011***	(-4.11)	-0.011***	(-5.88)
Age band 8	-0.001	(-0.38)	0.003	(1.44)	-0.020***	(-7.40)	-0.004*	(-2.05)
Age band 9	-0.001	(-0.51)	-0.029***	(-13.62)	-0.027***	(-10.28)	-0.027***	(-14.36)
Household size band 1 (as base)	—		—		—		—	
Household size band 2	0.035***	(25.59)	0.020***	(21.20)	0.032***	(25.35)	0.021***	(22.74)
Household size band 3	0.043***	(26.56)	0.021***	(19.01)	0.036***	(23.79)	0.020***	(19.10)
Household size band 4	0.053***	(33.10)	0.032***	(29.58)	0.049***	(32.89)	0.035***	(33.85)
Household size band 5	0.076***	(37.23)	0.034***	(26.07)	0.063***	(33.22)	0.033***	(26.68)
Household size band 6	0.088***	(30.49)	0.037***	(22.46)	0.065***	(24.11)	0.033***	(21.12)

* p<0.05 ** p<0.01 *** p<0.001

Appendix 1

Heckman model for Model 1

The quantity of healthy food consumption is observed if and only if the consumer decided to buy healthy food instead of unhealthy food. Hence, the Heckman model is adopted to deal with sample selection issue. We develop an equation for consumption of healthy food as

$$Q_{i(Heahlthy)} = \beta' X_i + \mu_i \,;\ \mu_1 \sim \text{N } (0, \sigma) \qquad \text{(A1)}$$

where $Q_{i(Healthy)}$ is the quantity of healthy food consumption of household *i*. X_i is a vector of observed variables that determines household *i*'s consumption of healthy food. Specifically, it includes price changes (remained the same, went up, went down), coupon usage, nutrition claim, store types, social class, age bands, household size bands. m_l is an error term.

$Q_{i(Healthy)}$ is observed if and only if consumers select healthy food, we specify the selection equation as:

$$s_i = \begin{cases} 1 & \text{if} \quad \alpha' \text{W}_i + \nu_i > 0 \\ 0 & \text{if} \quad \alpha' \text{W}_i + \nu_i \leq 0 \end{cases} \quad ;\ \nu_1 \sim (0, 1) \qquad \text{(A2)}$$

where s_i is a latent variable measuring the propensity to consume healthy food. W_i is a vector of covariates that affect consumers' healthy food choice. In detail, it includes standardized unit price, coupon usage, nutrition claim, store types, social class, and age bands. n_i is an error term for selection equation.

Thus the expected demand quantity for healthy food in (A1) is conditional on selection, i.e.:

$$\begin{aligned} E[Q_{i(Heahlthy)} \mid \beta'_i, s = 1] &= E[Q_{i(Heahlthy)} \mid s_i, \alpha' W + v_i > 0] \\ &= \beta' X_i + E[\mu_i \mid v_i > -\alpha' W_i] \quad \text{and corr } (\mu_i,\ \nu_1) = \rho \ \text{(A3)} \\ &= \beta' X_i + (\rho\sigma)[\phi(\alpha' W_i) / \Phi(\alpha' W_i)] \end{aligned}$$

The parameter coefficient ρ measures the correlation between the error terms μ_1 and ν_1, while σ measures the standard deviation of the residual term ν_1.

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