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Asymmetric Demand Patterns for Products with Added Nutritional Benefits and Products without Nutritional Benefits

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Abstract

This paper investigates consumers' demand patterns for products with nutritional benefits and products with no nutritional benefits across processed healthy and unhealthy foods. We integrate price changes (i.e. increases and decreases) into a demand model and quantify their relative impact on the quantity of food purchased. Firstly, we investigate how demand patterns vary across processed healthy and unhealthy products; secondly, we examine how demand patterns vary across nutrition-benefited products (NB) and non-nutrition-benefited products (NNB); and thirdly, we investigate how consumers respond to price increases and decreases for NB across processed healthy and unhealthy foods.

Design/methodology/approach: We propose a demand model quantifying scenarios for price changes in consumer food choice behavior, and controlling for heterogeneity at household, store and brand levels.

Findings: Consumers exhibit greater sensitivity to price decreases and less sensitivity to price increases across both processed healthy and unhealthy foods. Moreover, the research shows that consumers' demand sensitivity is greater for non-nutrition-benefited products (NNB) than for nutrition-benefited products (NB), supporting our prediction that NB has higher brand equity than NNB. Furthermore, the research shows that consumers are more responsive to price decreases than price increases for processed healthy NB foods, but more responsive to price increases than price decreases for unhealthy NB foods. The findings suggest that consumers exhibit a desirable demand pattern for products with nutritional benefits.

Originality/value: Although studies on the effects of nutritional benefits on demand have proliferated in recent years, researchers have only estimated their impact without considering the effect of price changes. This paper contributes by examining consumers' price sensitivity for nutrition. Benefited products (NB) across processed healthy and unhealthy foods based on consumer scanner data, considering both directionalities of price changes.

Keywords: Price change; Demand pattern, Nutritional benefit

Introduction

The number of overweight adults has increased by about 50% in the US in the last 35 years, and 35.9% of adults are now obese (OECD Health Data, 2014). Such epidemic levels of obesity are partially due to the increased consumption of unhealthy food and decreased levels of exercise [1]. Public policymakers have thus endeavored to propel consumers towards healthier food choices by designing economic intervention tools (e.g. placing surcharges and subsidies on food products), and regulatory tools (e.g. implementing nutrition labeling regulations) [2,3]. Successful design of both types of tools needs a clear understanding of how food price and added nutritional benefits (e.g. products with low fat, reduced sugar, or high fiber) nudge consumers' food consumption behavior.

The healthiness of food can be measured by whether the product is relatively healthy or relatively unhealthy and whether the product conveys nutritional benefits. A healthy food, according to UKFSA [4], "must be low in fat and saturated fat and contain limited amounts of cholesterol and sodium. In addition, if it's a single-item food, it must provide at least 10 percent (of the Daily Reference Value) of one or more of vitamins A or C, iron, calcium, protein, or fiber". Food categories that do not satisfy this definition are seen as relatively unhealthy. This general definition is consistent with the survey findings of [5], which categorize 120 foods in one of six positions ranging from relatively unhealthy to relatively healthy. For example, the healthiness score of yoghurt ranges from 4.37 to 4.76 (relatively healthy) and that of packaged potato chips ranges from 1.47 to 2.36 (relatively unhealthy). Moreover, the healthiness of food can be further measured by its nutritional benefits. Nutritional benefits as identified in this study refers to special nutrient qualities of a product such as "low in/reduced fat", "low in/reduced sugar", "low in/reduced calorie", "low in salt" and "high in fiber". It is noteworthy that both healthy and unhealthy foods can convey nutritional benefits, which provide criteria for a more nuanced classification within healthy and unhealthy foods. For example, low-fat potato chips (nutrition-benefited) are perceived as healthier than regular potato chips (non-nutrition-Benefited) [1,5], though both products belong to the category of unhealthy food. Therefore, two dichotomizations (healthy/unhealthy and nutrition- benefited/non-nutrition-benefited) can be used to classify products into 4 types: (1) healthy nutrition-benefited products refer to products with nutritional benefits in healthy food (e.g. low-fat yoghurt), (2) healthy non-nutrition-benefited products refer to products with no nutritional benefits in healthy food (e.g. regular yoghurt), (3) unhealthy nutrition-benefited

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products refer to products with nutritional benefits in unhealthy food (e.g. low-fat potato chips), and (4) unhealthy non-nutrition-benefited products refer to products with no nutritional benefits in unhealthy food (e.g. regular potato chips).

Marketing research on the effect of nutritional benefits on consumers' demand patterns has proliferated in recent years. Despite this, marketing researchers have given only intermittent attention to examining this effect in the real market setting. Generally, participants in experiments do not have to pay for the food and, even if they do pay, price is rarely included in the analysis. Therefore, price changes are often excluded from experiments examining causal relationships between added nutritional benefits and food intake because they are not connected with the food ingredients [6-10]. These studies do not discuss the possibility of an asymmetric demand pattern, which refers to different responses by consumers to price increases and decreases. In contrast, our study takes market factors (e.g. price) into consideration and facilitates the understanding of how added nutritional benefits affect consumers' buying behaviour according to the directionality of price changes.

Moreover, marketing research has evidenced how brand characteristics affect consumers' responses. Factors such as brands' purchase frequency, price position, price volatility, share of budget, storability and perceived differentiation, among other factors, have been found to have a significant impact on price elasticities [11-13]. For example, Fok *et al.* found that consumers are less sensitive to price discounts for brands with high price differentiation that constitute a smaller share of the budget. Despite this, marketing researchers have given scant attention to the question of how nutritional benefits affect consumers' demand response. Put differently, given that conveying nutritional benefits is a characteristic that differentiates a brand from its counterparts, does the price elasticity of nutrition-benefited products (NB) differ from that of non-nutrition- benefited products (NNB)?

Most previous nutrition and food consumption studies focus on observing consumption behaviour related to individual products (e.g. mostly unhealthy ones) or how the presence of nutritional benefits affects total calorie consumption [7,9,14]. However, in the real marketplace, consumers rarely buy just one product, and the purchase of one product might influence the purchase of another one. Ma et al. indicated that consumers with type 2 diabetes are more likely to trade off one type of unhealthy food (e.g. clotted cream) with another (e.g. cola). This leaves unaddressed questions: what are consumers' demand patterns for nutrition-benefited products (NB) and for non-nutrition-benefited products (NNB)? How do these demand patterns for NB and NNB vary across healthy and unhealthy foods?

This study aims to answer these unaddressed questions by predicting that consumers' demand patterns are asymmetric for healthy and unhealthy foods. The contention of asymmetric demand pattern has been underdeveloped in marketing literature, which shows a potential danger of assuming consumers' demand sensitivity regardless of the directionality of price change [6,15,16]. Such an assumption can lead to misunderstanding about the complexity of price- change effects. Marketing research related to internal reference price (IRP) broadens the understanding of asymmetric demand pattern. The IRP is a reference price that consumers create according to a previously encountered price [17-20]. When the IRP is higher than the purchase price, it is perceived as a gain; when IRP is lower than the purchase price, it is perceived as a loss. A phenomenon, loss aversion, has noted that losses (a price increase) exert a greater effect on consumers' value functions than do gains (a price decrease) [21-23].

However, empirical evidence shows that consumers are more sensitive to price decreases than price increases, which is contradictory to the theory of loss aversion, indicating that loss aversion is not a universal phenomenon [17,20,24]. More importantly, we do not know if loss aversion holds true across healthy and unhealthy products or if loss aversion holds true for nutrition-benefited products. Research is needed to generate findings that incorporate nutritional benefits and examine which asymmetric demand patterns are generated by healthy and unhealthy products.

The only study we have found to date related to asymmetric demand patterns for healthy and unhealthy products using scanner data is that of Talukdar and Lindsey [25]. They developed their hypotheses based on impulsive consumption theory, which posits that consumers are more sensitive to a price decrease than a price increase in unhealthy food due to the natural impulse to overconsume unhealthy food; and consumers are more sensitive to a price increase than a price decrease in healthy food due to the natural impulse to underconsume healthy food. This is an important empirical finding that loss aversion is category dependent. It explains theoretically why consumers exhibit loss aversion for healthy food and the opposite pattern for unhealthy food.

Our study differs in several ways. Firstly, the study by Talukdar and Lindsey [25] focused mainly on non-processed healthy products (e.g. broccoli, grapes) but not processed ones (e.g. yoghurt, fruit juices). Processed food refers to any food that has been changed from its natural state for reasons of convenience or safety (UKNHS 2014, e.g. apple juice). In contrast, a non-processed food is any food that has not been changed from its natural state (e.g. an apple). Our observations do not focus on non-processed healthy products, because they are less likely to convey certain nutritional factors such as fat (e.g. broccoli) and/or have a healthier version (e.g. grapes). In order to take into account the effects of added nutritional benefits, we focus our observation on processed healthy and unhealthy products that contain nutritional content such as fat, sugar and fibre and for which there is a healthier version (e.g. low-fat yoghurt, low-fat chips) [2]. Moreover, it is important to know that processed healthy products (e.g. yoghurt) are considered as belonging to the healthy food category in the existing literature [5]. Therefore, we propose that our hypotheses are based on more nuanced classifications by further dividing the processed healthy and unhealthy categories into four distinct subcategories: processed healthy NB and NNB and unhealthy NB and NNB. We thus are able to examine how consumers' price sensitivities differ across products with claimed nutritional benefits and those without such claims. Finally, we investigate how NB impacts consumers' asymmetric demand patterns by examining consumers' price sensitivity to a price increase and to a price decrease with respect to nutrition-benefited products.

In a similar fashion to Talukdar and Lindsey [25], we look across multiple purchases to facilitate using last price paid as reference price. Moreover, we also take brand/category, consumer and store heterogeneity (e.g. brand type, brand loyalty, coupon usage, nutritional benefits, store type, consumers' brand loyalty, shopping frequency, etc.) into account since these factors also affect consumers' price sensitivity [11-13,25-27].

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 patterns and price changes for nutrition-benefited and non-nutrition- benefited products. Section 3 discusses the data used, which comprise consumer transaction records, product attribute information and consumer demographic characteristic information from the UK Taylor Nelson

Sofres (TNS). This is followed by estimating a set of demand models in Section 4. The paper concludes by discussing the implications for theory and practice.

Theoretical Development and Hypotheses

Desirable and undesirable demand patterns

From health policymakers' viewpoint, a desirable demand pattern is one that persuades consumers to purchase more healthy food, while an undesirable one does the opposite [25]. To determine by observation whether a consumer demand pattern is desirable or undesirable, one must first clarify how changes in price affect consumers' demand patterns. Price changes are perceived by consumers in terms of how they differ from the consumer's internal reference price [28-30]. As Mazumdar et al. [31] proposed, we consider the last purchase price as the consumer's internal reference price to define whether the price has changed, so each consumer has a relatively different reference price from another consumer for the same product. The examples in Figure 1 denote three types of demand pattern. In Type 1, price elasticity is symmetric; i.e. when prices rise or fall the same price elasticity is observed. Most prior research assumed this pattern to be valid without considering price elasticity may be asymmetric across scenarios when prices rise and when prices fall [6,15,16]. However, two other types of demand pattern have received intermittent attention.

In 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 to a fall in price than to a rise in price relative to the last purchase. Some prior studies have found empirical evidence to support this pattern, indicating that this pattern is applicable if consumers exert brand loyalty towards a brand [20] are unfamiliar with the promotion frequency or the product's own price volatility [24,32,33] and/or are less likely to "discount" price promotion [34] or if consumers exhibit a natural impulse to "overconsume" unhealthy food [25].

In 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. Some prior studies found this pattern is applicable if price changes are small enough to be maintained within the latitude of acceptance [21]; if the IRP is separately modelled [22]; if consumers weight losses (from paying a higher price than the last purchased price) more than equivalent-sized gains (from paying a lower price than the last purchased price) for a product [19]; or if consumers exhibit a natural impulse to "underconsume" healthy food (e.g. broccoli) [25]. In this pattern, consumers are more sensitive to a rise in price than to a fall in price 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 a particular healthy food or a particular unhealthy food is identical under symmetric and asymmetric scenarios, the quantity purchased can differ considerably across these three circumstances [25]. 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, the price elasticity varies with the movement in price. Hence, a consumer's demand pattern is more complex if his or her demand sensitivity is asymmetric, meaning price elasticity differs between scenarios where the price increases and those where the price decreases. 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 for public policymakers to implement economic policy tools such as surcharges and subsidies on food products to encourage healthy food consumption and discourage unhealthy food consumption [25,35-37]. Identifying consumer demand patterns provides a method to predict the efficiency and effectiveness of these tools (Table 1).

Asymmetric demand patterns

Our study hypothesizes that consumers' price elasticity is greater for a price increase than for a price decrease for processed healthy food, but it is less for a price increase than for a price decrease for unhealthy food. First of all, we draw on internal reference price literature to demonstrate why consumers exhibit an asymmetric demand pattern. Secondly, drawing on impulsive demand theory, we demonstrate that the asymmetric demand patterns are product category dependent. Thirdly, we argue that due to the impulse to under consume healthy food and to over consume unhealthy food, consumers are more sensitive to price increases than to price decreases for processed healthy products and this demand pattern is reversed for unhealthy products.

The existence of an internal reference price has important implications for consumers' asymmetric demand patterns [17]. The IRP is "a price that consumers are assumed to form in their minds as a

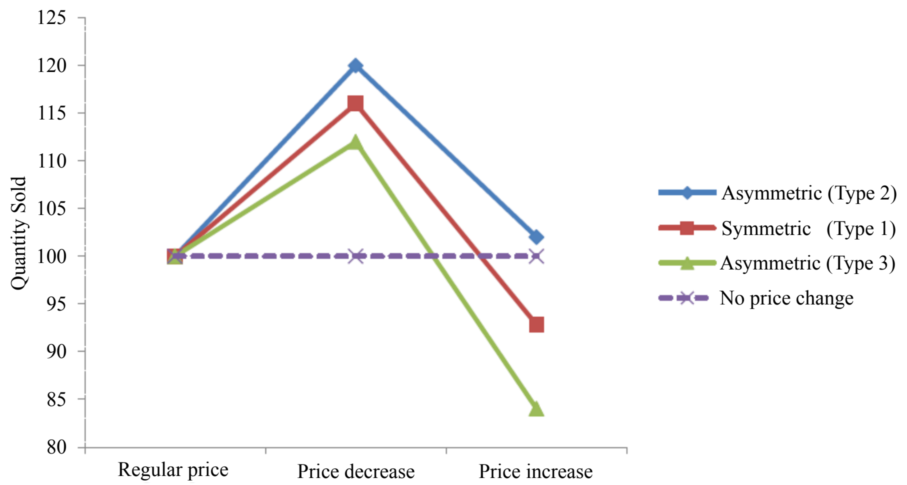

Figure 1: Examples of demand patterns.

Demand Pattern	Healthy Food	Unhealthy Food
Desirable	Consumers are more sensitive to price decrease than price increase	Consumers are more sensitive to price increase than price decrease
Undesirable	Consumers are more sensitive to price increase than price decrease	Consumers are more sensitive to price decrease than price increase

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

result of experience" [19]. Most researchers measure it as the price for that brand on the last purchase occasion [18]. Consumers compare the price of a product with their internal reference price to decide whether purchasing this product is a gain (the purchase price is smaller than IRP) or a loss (the purchase price is greater than the IRP). Prospect theory [38] predicts a loss aversion phenomenon in which consumers respond more to losses than to gains. Loss aversion (see Type 3 in Figure 1) has been supported empirically [21-23] but it is also been challenged by contradictory findings that consumers are more responsive when the purchase price is smaller than the IRP than vice versa. A possible reason for the contradiction is that asymmetric demand patterns are found to be "context dependent" [20]. For example, consumers' asymmetric demand patterns for a price increase and for a price decrease depend on brand loyalty [19,20]; Müller and Ray [33], shopping frequency [19,24], brand type [34], brand market share [24], brand's own price volatility/ promotion frequency [24,32,33] and shopping context [24].

In addition to these contexts, we argue that consumers' asymmetric demand patterns are also category dependent [17,25]. Food categories differ across healthiness level and palatability, which have different impacts on the demand pattern. According to impulsive demand theory, natural impulses in food consumption are driven by perceptual and sensory differences in the palatability of food. Hence, consumers naturally tend to overconsume unhealthy food and underconsume healthy food because the perceptual and sensory pleasures of unhealthy food are higher than those of healthy food [39]. For example, Talukdar and Lindsey [25] found that consumers' price elasticity is higher for a price decrease than for a price increase for unhealthy food; but consumers' price elasticity is greater for a price increase than for a price decrease for healthy food. In other words, consumers employ loss aversion for healthy food categories but show the opposite pattern (more sensitive to price decreases than price increases) for unhealthy food. Due to their different research focus, empirical evidence supporting Talukdar and Lindsey's [25] argument on demand patterns is largely focused on non-processed healthy (e.g. broccoli) and unhealthy products, while our study focuses on processed healthy (e.g. yoghurt) and unhealthy products.

We argue that although processed and non-processed healthy products differ in many respects (e.g. there is fat content in yoghurt but no such content in broccoli), both processed (e.g. yoghurt) and non-processed (e.g. broccoli) healthy products are perceived as healthy food in the existing literature [5,40]. Following impulsive demand theory, we propose that because the palatability of processed healthy food (e.g. yoghurt) is lower than that of unhealthy food (e.g. potato chips), consumers are more likely to underconsume processed healthy food and more likely to exhibit an impulse to overconsume unhealthy food. This prediction is thus congruent with prior findings that loss aversion is applicable for the healthy food category [25] but not applicable for the unhealthy food category [17]. Hence, we argue that consumers place a higher value on losses (when prices go up) than gains (when prices go down) for processed healthy food but a higher value on gains than losses for unhealthy foods.

Hence, our first hypothesis predicts that:

H1: Consumers' price sensitivity is greater when prices go up than when prices go down for processed healthy food, while their price sensitivity is greater when prices go down than when prices go up for unhealthy food.

Demand patterns for NB and NNB

Our study hypothesizes that the price elasticity of products with nutritional benefits is lower than that of products without nutritional benefits. This effect is argued through two contentions: NB has stronger brand equity than NNB, and products with stronger brand equity have lower price elasticity than their weaker counterparts (Figure 2).

To demonstrate the first contention, we need a clear understanding about what is meant by "nutritional benefit". Added nutritional value can be claimed on a food label and presented as a nutritional benefit, suggesting or implying that the food has "particular beneficial nutritional properties" due to the energy and the nutrients it provides or constrains [41]. Figure 2 indicates some examples of low-fat and reduced- sugar benefits. Both healthy and unhealthy foods [3] can have nutritional benefits. For example, low-fat yoghurt is categorized as a healthy product and low-fat potato chips as an unhealthy product. Some researchers believe that nutritional benefits claimed for products have a direct and significant impact on food choice in terms of increasing healthy purchases [42-45]. However, some researchers suggest that the direct influence of nutritional benefits on levels of healthy food consumption may be subject to the influence of food types, individual differences, brands, how the nutrition claim has been understood, and even the geographic regions where studies are conducted [9,46,47]. In this study, we consider the question of how nutritional benefits influence consumers' demand patterns.

One important feature of NB products is that only when recognized nutrient ingredient changes have been applied can a nutrition claim be

Figure 2: Examples of nutritional benefits conveyed on food packaging.

made on food packaging due to severe scrutiny of public policymakers [48]. For example, a claim of "low in fat" can only be used on product packaging when the product contains 3 grams or less of fat per 100 grams of solids, or 1.5 grams or less of fat per 100 ml for liquids (European Commission, 2006). Such claims can differentiate a brand, enhance its value proposition, and block competitors [49,50]. Therefore, added nutritional benefits have a significant positive impact on brand equity. Put differently, NNB products do not benefit from conveying such positive brand image due to a lack of nutritional benefits. This explains why consumers generate a favourable association between healthier living and NB products. Moreover, the notion that consumers demonstrate better brand valuation and perception of NB than NNB has been supported by nutrition labelling studies across healthy and unhealthy foods [10,44,45]. The belief that nutritional benefits indicate a healthier product also improves brand evaluation [8,9,51]. Therefore, products with nutritional benefits (NB) are evaluated more highly by consumers than those without such claims (NNB).

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" [52]. The first refers to consumers' psychological evaluations of a brand—their awareness, attitudes, associations, attachments, and loyalties [49,53]; and the latter two (product-market outcomes and financial market outcomes) focus on the net benefit obtained by a firm or retailer from the equity of its brands. The theoretical argument of this study is consumer-oriented that relies on consumers' perception of the healthfulness of foods, their perception of the internal reference price, their sensitivity to price changes and their psychological evaluation of brands; therefore the first measure is more important than the other two for this study. Following the "customer mind-set" measure of brand equity, that consumers' psychological evaluation of NB is higher than that of NNB lends strong support to the contention that NB products have stronger brand equity than NNB.

The second contention, that stronger brand equity products have lower price elasticity than their weaker counterparts, is derived from the brand equity literature [49,53,54]. In particular, higher prices can be charged for stronger brand equity products than for non-branded or weakly branded products. For example, consumers are more willing to pay premium prices for the brand to which they have a strong, favourable brand attitude than one to which they don't have strong positive association [49,55,56]. The previous argument is also supported by Ailawadi et al [54] that "high equity brands should have lower price elasticities than low equity counterparts". These findings are in line with the argument that the price elasticities of strong brand equity products are smaller than those of weak brand equity products.

Associating the two contentions that NB products have higher brand equity than NNB products and stronger brand equity products have lower price elasticity than weaker brand equity products, we predict that NB products have lower price elasticity than their non-nutrition-benefited counterparts. Consumers should show greater demand response sensitivity to NNB products than to NB products across processed healthy and unhealthy foods. Thus:

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

Asymmetric demand patterns for NB

Our study hypothesizes that consumers' price sensitivity is greater for a price decrease and less for a price increase for NB products across processed healthy and unhealthy food categories. This asymmetric effect is argued through two notions: NB products are established and perceived as high equity brands (see relevant arguments in previous section), and high equity brands have smaller price elasticity for a price increase (the "up" own-price elasticity, i.e. the effect on demand when price is increased) than for a price decrease (the "down" own-price elasticity, i.e. the effect on demand when price is decreased).

High equity brands have smaller "price up" elasticity than "price down" elasticity is supported by marketing literature [24,49,54]. Put differently, the demand pattern for high equity brands is asymmetric across scenarios when prices go up and when prices go down. Keller [53] proposed that "a positive image should enable the brand to command larger margins and have more inelastic responses to price increases". His argument is based on the belief that strong attributes or benefit associations for the brand require less reinforcement through marketing communications. This suggests that a high equity brand may need only a small price decrease to trigger increases in demand. Pauwel et al. [24] provided empirical evidence to support this proposition: smaller price decreases need to be offered for high equity brands to increase sales, as consumers are highly responsive to even a small gain provided by a highly reputable brand. In the same line, Gupta and Cooper [34] found consumers do not tend to discount price decreases for high equity brands. Moreover, consumers are believed to have a greater level of tolerance for price increases for high equity brands, so they are less responsive to price increases for high equity brands [24]. This notion is also supported by a study of 23 consumer packaged goods over 7 years, which reported that "the 'price up' elasticity is significantly smaller in magnitude (less negative) than the 'price down' elasticity for high equity brands" [54]. The literature lends strong support to our second contention that the effect on sales when the price is increased is significantly lower than the effect on sales when the price is decreased for high equity brands.

To consolidate the argument, since NB products are perceived having high equity, their positive image should allow the brand to generate larger margins to have elastic responses to price decreases and more inelastic responses to price increases, which is in line with the finding that strong brand equity products have smaller "price up" elasticity than "price down" elasticity [54]. Both contentions in this argument are supported by prior studies [24,34,53,54]. As for the "up" own-price elasticity, NB product managers invest in food nutrient improvement technology and package design (flagging up nutritional benefits) aimed at establishing differentiation and reinforcing consumers' favourable brand attitude. Such a strong and positive brand attitude towards NB engenders greater acceptance of price increases; consumers should be more willing to pay premium prices for NB and be less sensitive to price increases. As for the "down" own-price elasticity, the positive brand image of NB related to healthier living creates a large consumer base to react to price decreases. Benefits associated with NB products engender a positive evaluation and reinforce their good reputation. Hence, consumers react more favourably to gains (price decreases) than to losses (price increases) for NB products.

Based on this argument that NB products have strong brand equity and high equity brands have smaller price elasticity for a price increase than for a price decrease, our third hypothesis is:

H3: Consumers exhibit greater price sensitivity for a price decrease and less price sensitivity for a price increase for NB products, with regard to (a) processed healthy food and (b) unhealthy food.

Methods

Data collection and sample

To test the above hypotheses the sample chosen had the following characteristics. Firstly, we focused on packaged products such as biscuits, packaged potato chips and yoghurt, because non-packaged food is unlikely to include nutrition information. It is noteworthy that some observations in this study are from nutrition-benefited products and other observations are from non-nutrition-benefited products, because both types (NB and NNB) existed in each product category. Secondly, 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 impacts of price on the healthfulness of food choice. Thirdly, store type is closely related to the availability of healthy food or healthier food options, and thus the sample included convenience, discount and drug stores as well as grocery stores.

The study used data from Taylor Nelson Sofres (TNS). Four sources were combined in our analysis. Dataset 1 is a transaction dataset collected by TNS from 6,218 UK households over 52 weeks (4) including more than 0.8 million transaction data points. Dataset 2 comes from a survey conducted by TNS documenting the demographic information for participating households (5). Hence, we were able to use food transaction data while controlling for consumers' individual heterogeneity. We linked datasets 1 and 2 by using household panel ID numbers. Dataset 3 is a product attribute file listing information such as nutritional benefits. We linked Dataset 3 with datasets 1 and 2 by using product codes. Dataset 4 is a store information file and we also used product codes to link Dataset 4 with datasets 1, 2 and 3. Table 2 presents key sample descriptive statistics (Table 2).

Measures

Healthiness of food choices: We adopted one of the most thorough nutrient profiling survey results from Scarborough et al. [5] to sort the food categories in this study into healthy and unhealthy foods. To be representative of the British diet, the survey questionnaires included 120 foods, and the questionnaire asked nutrition professionals (with 850 usable responses) from the British Dietetic Association and the (British) Nutrition Society to categorize the 120 foods into one of six positions, ranging from less to more healthy. In accordance with the survey results, food types in this study are categorized into healthy and unhealthy food categories (6). Table 2 presents descriptive statistics of a list of healthy and unhealthy food categories. We adopted Scaborough et al. [5] health score to indicate the healthiness of products from 6 (healthiest) to 1 (unhealthiest).

Moreover, to make the individual transaction data across products commeasurable within a product category, we built a quantity index, *Quantity*, to measure the quantity purchased of a product. In accordance with the methods used by [55-57] this was calculated as *Quantity Ratio=actual quantity purchased per shopping trip per product/the average quantity purchased in one food category*. The purpose of generating a ratio of quantity is to avoid comparing different quantity units across different brands.

Nutritional benefits: In our sample, each product can be associated with a product attribute file through the product code. In the product attribute file, a set of variables describe the characteristics of the products, such as package size, organic, fair trade and nutrient-specific variable. The nutrient-specific variable indicates information including "low in/reduced fat", "low in/reduced sugar", "low in/reduced calorie", "low in salt" and "high in fibre" in our sample. For example, we found "low in sugar" in the product attribute file for baked beans and "reduced fat" in the product attribute file for crisps. We thus used this nutrient-specific variable to identify whether a product contained nutritional benefits. *A nutritional benefit is* coded as 1 when the nutrient-specific information is present and as 0 when it is not present. It is noteworthy that different nutrition benefits may affect demand patterns differently. The focus of this study is to investigate the differences between nutrition- benefited products and non-nutrition-benefited products. Hence, we do not specify different types of nutritional benefits in our sample.

Price Index and Price Changes: Price Index is measured by a price ratio, *Price Index=Price/Quantity Ratio,* indicating a standardized unit price paid for a product in a single transaction. *Price* refers to the unit price paid by a consumer in one shopping trip on one product per relevant quantity (e.g. ml, g, kg). *Quantity Ratio* is the same as described previously. We used 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 Index/Quantity Ratio)/actual quantity purchased per shopping trip per product.*

As illustrated previously, we use consumers' last purchase price of each brand as their internal reference price (IRP), which is in line with most prior [18,20,23]. Put differently, the first purchase provides the internal reference price for the analysis of the second purchase. It is noteworthy that we measure the IRP at the brand level instead of category level, which allows us to control for brand-level characteristics (e.g. nutrition benefits, national/store brand) in our analysis. The brand-level IRP measurement method produces fewer usable observation numbers than category-level IRP measurement, since purchases were excluded from the analysis due to being the first purchase or being the only purchase (for details, see Table 2).

Hence, price changes are measured by whether the price paid for brand A at time t is different from the price paid for the same brand at time $t-1$, which is in line with using the last purchase price to define whether the price has changed [58,59]. Hereafter, if $Pricetime\ t-Pricetime\ t-1 \neq 0$, it indicates the price for this product has changed since the last time the consumer purchased it. Moreover, we use price movement indicator (PMI) variables to measure three conditions of price movement related to the current price and last price paid by a household. Following Talukdar and Lindsey [25], PMI comprises (1) remains the same (PS), (2) price went up (PU), and (3) price went down (PD)

Control variables: We included several variables that affect price elasticity in our analysis, comprising consumer-related variables (social class, age group, household size, shopping frequency and brand loyalty) and marketing variables (store category, brand type and coupon usage). It is important to note that the price index used for our calculation is the actual price paid per unit of food, which has taken coupon usage into consideration. Moreover, 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 the consumer repurchases product A at time *t+1*, this product is still priced at *p*', but he or 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 less expensive than *p*'−5p paid at time *t+1*. A full list of variables included in our analysis is displayed in Table 3.

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Product Category	Milk	Fruit Juices	Yoghurt	White Bread	Biscuits	Crisps	Cream
lnQ† (Quantity purchased)							
Mean	0.78	0.02	-0.81	0.71	-1.17	1.85	-0.69
Std.	0.71	0.73	0.69	0.52	0.73	0.99	0.65
Min	-1.39	-1.9	-2.16	0.01	-4.14	0.01	-2.18
Max	3.87	3.18	2.08	3.47	2.48	5.01	2.56
PU† (Prices went up)							
Mean	-0.27	0.23	0.59	-0.7	0.89	-1.39	0.55
Std.	0.45	0.61	0.64	0.68	0.94	1.03	0.66
Min	-3.96	-2.51	-3.47	-5	-3.34	-4.83	-2.81
Max	2.14	2.81	2.98	1.65	4.87	1.53	2.74
PD† (Prices went down)							
Mean							
Std.	-0.06	-0.01	0.02	-0.09	0.01	-0.08	0.01
Min	0.27	0.13	0.18	0.39	0.2	0.43	0.13
Max	-2.91	-1.97	-2.18	-4.36	-3.03	-4.22	-2.6
	1.96	2	2.17	1.14	3.82	0.68	2.16
PNB† (Prices for NB)							
Mean							
Std.	-0.07	0.03	0.13	-0.33	0.15	-0.36	0.07
Min	0.3	0.26	0.39	0.59	0.52	0.79	0.31
Max	-2.88	-1.97	-2.18	-4.36	-3.03	-4.22	-2.6
	2.14	2.77	2.98	1.18	3.85	1.38	2.64
PNNB† (Prices for NNB)							
Mean							
Std.	-0.15	0.01	0.04	0.01	0.01	0.01	0.02
Min	0.37	0.12	0.24	0.04	0.11	0.1	0.14
Max	-2.91	-1.81	-1.81	-2.5	-0.84	-3.03	-0.74
	1.96	2.16	2.18	0.01	2.87	0.86	2.01
PUNB† (Prices up for NB)							
Mean							
Std.	-0.27	0.12	0.49	-0.84	1.18	-1.29	0.86
Min	0.43	0.54	0.62	0.66	0.87	1.12	0.65
Max	-3.96	-2.46	-2.27	-3.1	-1.07	-3.99	-1.27
	2.08	2.34	2.9	0.16	3.12	0.86	2.21
PDNB† (Prices down for NB)							
Mean							
Std.	-0.06	-0.01	0.01	-0.11	0.03	-0.04	0.01
Min	0.26	0.12	0.17	0.38	0.22	0.29	0.09
Max	-2.91	-1.81	-1.81	-2.5	-0.79	-3.03	-0.62
	1.85	1.24	2.17	0.01	2.87	0.01	1.54
SF (Shopping frequency)							
Mean	88.05	24.23	53.73	47.4	62.17	26.93	16.72
Std.	90.43	24.68	42.33	32.53	48.67	19.39	22.65
Min	12	12	12	12	12	12	12
Max	603	178	362	347	391	114	169
BL† (Brand loyalty)							
Mean	1.33	1.89	2.65	2.33	3.17	2.09	1.21
Std.	0.64	0.82	0.72	0.67	0.68	0.72	0.73
Min	0	0	0	0	0	0	0
Max	2.83	3.91	4.25	3.93	4.68	3.95	3.37

†Logarithms transferred number.
Note: Please see Table 3 for detailed variable definitions.

Table 2: Descriptive statistics.

Analysis

We estimated three household-level random effects models to quantify demand patterns across different food categories (for the model specification, see Table 3). In line with Talukdar and Lindsey [25], we conducted the analysis individually for each product category since product-level characteristics affect the responses to price changes. In total, 21 random effects regressions are estimated in log-log form.

Model 1: $lnQij=\beta10+(\beta11PSij+\beta12PUij+\beta13PDij)ln(Pij)+\beta14NBij+\beta15CUij+\beta16BTij+\beta17STij+\beta18SFij+\beta19BLij+\beta110SCij+\beta111ARij+\beta112HSij+\mu i+\varepsilon ij$			
Model 2 : $lnQ=\beta20+(\beta21PNBij+\beta22PNNBij)ln(Pij)+\beta24NBi+\beta25CUij+\beta26BTij+\beta27STij+\beta28SFij+\beta29BLij+\beta210SCi+\beta211ARij+\beta212HSij\mu i+\varepsilon ij$			
Model 3: $lnQ=\beta30+(\beta31PSij+\beta32PUNBij+\beta33PDNBij)ln(Pij)+\beta34NBij+\beta35CUij+\beta36BTij+\beta37STij+\beta38SFij+\beta39BLij+\beta310SCij+\beta311ARij+\beta312HSij+\mu i+\varepsilon ij$			
Quantity of Demand	Q	Quantity purchased in standard unit for each food category by household i in shopping trip j	Dataset 3
Standard Unit 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 product went up since last purchase	Dataset 1
	PD†	Price of product went down since last purchase	Dataset 1
Price Movement Indicators	PNB†	Price of nutrition-benefited product	Dataset 1
	PNNB†	Price of non-nutrition-benefited product	Dataset 1
	PUNB†	Price of nutrition-benefited product went up since last purchase	Dataset 1
	PDNB†	Price of nutrition-benefited product went down since last purchase	Dataset 1
Control Variables			
Product-related characteristics	NB	Nutrition claim—A dummy variable; equals 1 when a nutrition claim is present	Dataset 3
	CU	Coupon usage—A dummy variable; equals 1 when a coupon has been used	Dataset 1
	BT	Brand type—A dummy variable; equals 2 when a brand is a national brand; equals 1 when a brand is a standard store brand; equals 0 when a brand is a budget store brand or non-branded	
Store-related characteristics	ST	Store type—A categorical variable indicating five store types:	Dataset 4
		Convenience=1 if a product is purchased from a convenience store, e.g. Tesco Express	
		Discount=2 if a product is purchased from a discount store, e.g. Lidl	
		Grocery=3 if a product is purchased from a supercentre that primarily sells food, e.g. Tesco Extra	
		Drug stores=4 if a product is purchased from a retail store featuring a pharmacy and selling grocery items, e.g. Boots	
		Other stores=0 if a product is purchased from none of the above-categorized stores	
	SF	Shopping frequency—number of shopping trips made by household i for each category	Dataset 1
	BL†	Brand loyalty— Logarithms transferred number of brands purchased by household i for each category	Dataset 1
Consumer-related characteristics	SC	Social class—A classification measured from the occupancy of a household, divided into six socioeconomic statuses: from 1—highest to 6—lowest level.	Dataset 2
	AR	Age range—Age of the shoppers, divided into nine age bands: <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, divided into six size bands: 1, 2, 3, 4, 5 and 6+	Dataset 2
	μi	μi is household-specific random effects	
	εij	εij is random error term	
	β11 …β33	Model coefficients, where β11 estimates consumers' base level of own-price elasticity when price remains the same since last purchase; β12, β13 estimate how the base-level of price elasticity is affected by the price movement direction since last purchase; β21, β22 estimate how the base-level price elasticity is affected by the presence of nutritional benefits; β31 estimates consumers' base level of own price elasticity when price remains the same since last purchase for nutrition-benefited products; β32, β33 estimate how the base level of price elasticity is affected by the price movement direction since last purchase for nutrition-benefited products.	

†Logarithms transferred number.

Table 3: Regression model specifications and variable definitions.

The first model (Model 1) estimated quantity of food consumption for each product using PS, PU, and PD as key independent variables. The second (Model 2) estimated quantity of food consumption using PNB and PNNB as key independent variables. The third (Model 3) estimated quantity of food consumption using PUNB and PDNB as key independent variables. We also computed VIF values of variables used in our models, and the results suggest there is no concern of multicollinearity. Model 1 is used to observe consumers' demand response sensitivity for healthy and unhealthy foods when prices increase and decrease, relative to the last purchase. H_1 is tested by β_{12} and β_{13}, in Model 1, and both coefficients are expected to be negative; if the absolute value of β_{13} is larger than that of β_{12}, it indicates that consumers are moreresponsive to price decreases than to price increases since the last purchase (Table 3).

Model 2 is used to compare consumers' sensitivities across NB and NNB. H_2 is tested by β_{21} and β_{22}; if the absolute value of β_{21} is smaller than β_{22}, it indicates that price elasticities are smaller for NB than for NNB. Model 3 is used to observe consumers' demand response to price increases and price decreases for NB. Model 3 thus comprises three price change indicators: price of NB remains the same (PS) as base; price of nutrition-benefited products went up (PUNB) and price of nutrition-benefited products went down (PDNB). H3 is tested by β_{32} and β_{33}, in Model 3; if the absolute value of β_{32} is smaller than β_{33}, it indicates that consumers are more responsive to price decreases than to price increases since the last purchase with respect to nutrition-benefited products (Table 4).

Results

Our results (Tables 4-6) generally uphold the hypotheses as presented in Section 2. The parameter estimates of the coefficients are generally within the expectations concerning their direction and significance level. Coefficients of price elasticity parameters for all product categories are all negative, suggesting that consumers' demand patterns follow the law of demand. For processed healthy food and unhealthy foods (results of Model 1; see Table 4), the coefficients of the indicator for price change since last purchase are negative and significant (p<.01) when prices increased; the coefficients of the indicator for price change since last purchase are negative and significant (p<.01) when prices decreased. Moreover, the absolute value of β_{13} is larger than that of β_{12} in Model 1 across each individual product category, suggesting that consumers are more sensitive to price decreases than increases. Thus, H_1 is not supported for processed healthy food categories but is supported for unhealthy food categories (Table 5).

The coefficients of the indicators for price change since last purchase are negative and significant (p<.01) for NB and NNB. For each processed healthy product category (results of Model 2; see Table 5), the price elasticity for NNB is larger than that for NB. Hence, consumers respond more aggressively to price increases for non-nutrition-benefited products than for nutrition-benefited ones. This demand pattern for processed healthy food also holds true for each unhealthy food category. Thus, H_2 is supported across each processed healthy and unhealthy food category (Table 6).

As for the coefficients of the indicators for price change for NB, we found these to be negative and significant (p<.01) across processed healthy and unhealthy categories (results of Model 3; see Table 6). In particular, for processed healthy food, the results of Model 3 show that the coefficient of the indicator for price change since last purchase is smaller when the price increases than when it decreases for NB. Thus, H3 is supported for processed healthy food. However, this demand pattern of NB for processed healthy food does not hold true for unhealthy food. Namely, as seen in Table 6, the coefficients of the indicators for price change since last purchase when the price decreases are negative but insignificant (p>0.1), while the coefficients of the indicators for price change since last purchase when the price rises are negative and significant (p<.01) for unhealthy NB. This indicates that the coefficients of the indicators for price change since last purchase when prices decrease are smaller than those when prices increase for unhealthy NB. Thus, H3 is not supported for unhealthy food.

Dependent variable: Logarithms quantity of demand														
Processed Healthy Food Categories Coefficients Estimate (SE)							Unhealthy Food Categories Coefficients Estimate (SE)							
Independent Variables	Milk		Fruit Juice		Yoghurt		White Bread		Biscuits		Crisps		Cream	
Price remained same (as base)														
Price went up	-0.50**	-0.01	-0.59**	-0.03	-0.53**	-0.01	-0.29**	0	-0.37**	-0.01	-0.14**	-0.01	-0.52**	-0.03
Prices went down	-0.57**	-0.01	-0.73**	-0.03	-0.55**	-0.01	-0.43**	0	-0.48**	-0.01	-0.25**	-0.01	-0.76**	-0.04
Coupon usage	-0.12**	-0.02	0.11**	-0.02	0.01	-0.01	0.17**	-0.01	0.26**	-0.01	0.02	-0.01	0.14**	-0.03
Nutritional benefit	-0.03**	-0.01	-0.09**	-0.02	0.03**	-0.01	0.09**	-0.03	-0.28**	-0.02	-0.39**	-0.05	-0.32**	-0.04
Brand type-no brand/budget store brand (as base)														
Brand type - standard store brand	-0.46**	-0.01	0.02	-0.04	-0.20**	-0.02	-0.14**	-0.01	0.11**	-0.01	-0.32**	-0.04	0.83*	-0.37
Brand type - national brand		N/A	0.22**	-0.04	0.04*	-0.01	0.04**	-0.01	0.13**	-0.01	-0.50**	-0.04	0.28	-0.37
Store type –other store (as base)														
Store type –convenience store	0.32**	-0.04	1.00**	-0.22	0.25	-0.18	0.05+	-0.03	-0.12	-0.11	0.25*	-0.11	-0.39+	-0.22
Store type –discount store	0.53**	-0.04	1.16**	-0.21	0.17	-0.18	0.06*	-0.03	0.07	-0.11	0.68**	-0.1	-0.22	-0.22
Store type –grocery store	0.67**	-0.04	0.93**	-0.21	0.16	-0.18	0.10**	-0.03	0.09	-0.11	0.68**	-0.1	-0.07	-0.21
Store type –drug store	-0.88	-0.57	0.71**	-0.22	-0.02	-0.31	-0.19	-0.24	0.24+	-0.14	-0.43*	-0.17	N/A	
Shopping frequency	-0.00**	0	-0.01**	0	-0.01**	0	-0.01**	0	-0.01**	0	-0.01**	0	0.01**	0
Brand loyalty	-0.11**	0	-0.10**	-0.02	-0.05**	-0.01	-0.01*	0	0.01	-0.01	-0.18**	-0.01	0.01	-0.02
Social class 1 (as base)														
Social class 2	-0.01	-0.04	0.13	-0.18	-0.09	-0.06	0	-0.04	-0.07	-0.1	0.18+	-0.11	0.54*	-0.24
Social class 3	0.10**	-0.04	0.42*	-0.17	0.05	-0.06	0.14**	-0.04	-0.17+	-0.1	0.22*	-0.1	0.32	-0.23
Social class 4	0.23**	-0.04	0.15	-0.17	-0.01	-0.06	0.11**	-0.04	-0.16+	-0.1	0.22*	-0.1	0.03	-0.23
Social class 5	0.18**	-0.04	0.21	-0.17	-0.01	-0.06	0.19**	-0.04	-0.18+	-0.1	0.40**	-0.1	0.14	-0.23
Social class 6	0.20**	-0.04	0.41*	-0.19	0.09	-0.06	0.19**	-0.04	-0.22*	-0.1	0.38**	-0.11	0.40+	-0.24
Age band control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household size control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	0.05	-0.06	-1.05**	-0.28	-0.65**	-0.19	0.33**	-0.05	-1.11**	-0.15	1.35**	-0.16	-1.11*	-0.5
N	50696		4584		33805		55455		30730		13374		2588	
Chi-square	21553.369***		2171.812***		13741.085***		38573.688***		7629.003***		3636.635***		2345.669***	
p-value for chi	0		0		0		0		0		0		0	

Standard error in parentheses. + p<0.10 * p<0.05 ** p<0.01 Notes: N.A.=not applicable.

Table 4: Random-effects regression analysis results for quantity purchased: Model 1.

Dependent variable: Logarithms quantity of demand														
	Processed Healthy Food Categories Coefficients Estimate (SE)						Unhealthy Food Categories Coefficients Estimate (SE)							
Independent Variables	**Milk**		**Fruit Juice**		**Yoghurt**		**White Bread**		**Biscuits**		**Crisps**		**Cream**	
Price remained same (as base)														
Coupon usage	-0.26**	-0.02	-0.06**	-0.02	-0.32**	-0.01	-0.06**	0	-0.07**	-0.01	-0.31**	-0.01	-0.14**	-0.02
Nutritional benefit	-0.04**	-0.01	-0.26**	-0.02	-0.05**	-0.01	0.21**	-0.04	-0.20**	-0.02	0.33**	-0.05	-0.37**	-0.04
Brand type-no brand/budget store brand (as base)														
Brand type - standard store brand	-0.805** (0.005)		0.38**	-0.03	0.31**	-0.01	0.08**	0	0.47**	-0.01	0.50**	-0.02	0.57*	-0.26
Brand type - national brand	N/A		0.69**	-0.03	0.77**	-0.01	0.50**	0	0.73**	-0.01	0.73**	-0.02	0.25	-0.26
Store type –other store (as base)														
Store type –convenience store	0.46** (0.03)		1.06**	-0.17	-0.05	-0.13	-0.03	-0.02	-0.01	-0.06	0.07	-0.05	0.034	-0.16
Store type –discount store	0.72** (0.03)		1.03**	-0.17	-0.1	-0.13	-0.12**	-0.02	0.11+	-0.06	0.19**	-0.05	-0.08	-0.15
Store type –grocery store	0.92** (0.03)		1.01**	-0.17	-0.01	-0.13	0.02	-0.02	0.17**	-0.06	0.32**	-0.05	0.144	-0.15
Store type –drug store	-0.84	0.44	0.98**	-0.18	0.47*	-0.23	-0.13	-0.16	0.06	-0.08	-0.34**	-0.08	N/A	
Shopping frequency	-0.01**	0	-0.01**	0	-0.01**	0	-0.01**	0	-0.01**	0	-0.01**	0	0.01	-0.01
Brand loyalty	-0.06**	0	-0.04**	-0.01	-0.02**	0	-0.02**	0	-0.01**	0	0.01+	-0.01	0.02+	-0.01
Social class 1 (as base)														
Social class 2	0.17**	-0.03	0.26+	-0.15	-0.06*	-0.02	0.06*	-0.03	0.11+	-0.06	0	-0.05	-0.03	-0.1
Social class 3	0.14**	-0.03	0.65**	-0.14	-0.05+	-0.02	0.03	-0.03	0	-0.06	0	-0.05	0.05	-0.09
Social class 4	0.24**	-0.03	0.26+	-0.15	-0.07**	-0.02	0.01	-0.03	0.07	-0.06	0.04	-0.05	0.03	-0.09
Social class 5	0.20**	-0.03	0.31*	-0.15	-0.10**	-0.02	0.04+	-0.03	-0.01	-0.06	0.08+	-0.05	0.04	-0.09
Social class 6	0.24**	-0.03	0.39*	-0.16	-0.10**	-0.02	0	-0.03	-0.03	-0.06	0.04	-0.05	0.03	-0.09
Age band control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household size control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	-0.27**	-0.05	-1.32**	-0.23	-0.49**	-0.14	-0.32**	-0.03	-1.10**	-0.08	-0.94**	-0.07	-0.63+	-0.33
N	50696		4584		33805		55455		30730		13374		2588	
Chi-square	68864.367***		5809.793***		54505.220***		1.60e+05***		93828.366***		62510.614***		7840.072***	
p-value for chi	0		0		0		0		0		0		0	

Standard error in parentheses + p<0.10 * p<0.05 **p<0.01 Notes: N.A. =not applicable.

Table 5: Random-effects regression analysis results for quantity purchased: Model 2.

Discussion and Conclusion

Theoretical implications

This study aims to demonstrate a better and novel understanding of consumers' demand patterns for nutrition-benefited and non-nutrition-benefited products across processed healthy and unhealthy foods. Our research responds to the recent call to study large-scale consumer transaction data (Griffith and O'Connell) [60] from sample groups other than those consisting solely of North American undergraduate students [48]. Several important conclusions emerge from this study. Our results show firstly that consumers demand sensitivity across processed healthy and unhealthy foods varies according to whether prices rise or fall. Secondly, the results support that consumers' demand sensitivity is greater for non-nutrition-benefited products (NNB) than for nutrition-benefited products (NB). Thirdly, we found that demand patterns for NB vary across product categories in such a way that consumers' demand response sensitivity is greater for a price decrease than for a price increase for processed healthy NB, compared with the last purchase price, which is desirable for healthy food; as for unhealthy NB, consumers are more responsive to a price increase than to a price decrease, compared with the last purchase price, which is desirable for unhealthy food. Consumers thus exhibit a desirable demand pattern for food with nutritional benefits across processed healthy and unhealthy products. These 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 increase consumption and profit in the long term, and also to appreciate nutritional benefits as an important way to improve consumers' consumption of healthy food when accounting for price changes.

Our first finding provides compelling reasons to recognize the asymmetric demand pattern. Our argument and analysis complements that of Talukdar and Lindsey [25], who show that asymmetric demand patterns need to be examined across healthy and unhealthy foods. They found that consumers are more responsive to losses than to gains for healthy products but are more responsive to gains than to losses for unhealthy products. Our analysis includes processed healthy and unhealthy products but excludes non-processed healthy products due to the fact that these products (e.g. grapes, broccoli) are less likely to have a healthier version. We found that consumers are more responsive to gains (for a price decrease) than to losses (for a price increase) for both processed healthy and unhealthy foods, which is desirable for healthy food but undesirable for unhealthy food (Table 1). According to impulsive demand theory, consumers' responses towards foods differ according to the healthfulness and palatability of the foods. Thus the different asymmetric demand patterns across processed and non-processed healthy products may be due to their different healthfulness levels and palatability. Our findings support that the effect of the impulse to under consume is weaker for processed healthy products than for non-processed healthy ones. Furthermore, our findings relevant to unhealthy categories of foods are in line with Talukdar and Lindsey's [25]. Associating our findings with Talukdar and Lindsey's [25], we conclude that demand patterns are similar across processed healthy and unhealthy products but differ across processed and non-processed healthy products. Therefore, consumers' asymmetric demand pattern is category dependent, which is congruent with most prior asymmetric demand pattern studies [17,20,24].

On one hand, the empirical findings of this study contribute to the existing empirical literature of loss aversion by supporting the view that loss aversion is not a universal phenomenon in fast-moving consumer goods (FMCG) [17]. On the other hand, it contributes to the internal reference price literature by demonstrating that the IRP is the deep-seated cause of consumers' asymmetric demand patterns. Moreover, our study is distinctive from most price promotion studies in that we examine the demand patterns for both directions of price movement, thus facilitating the identification of which pattern propels healthful food consumption. Hence, the nature of the asymmetric pattern revealed in this study contributes much needed theoretical insights for demand pattern studies.

Our second set of findings highlights how nutritional benefits influence consumers' price sensitivity. By comparing consumers' demand response sensitivity across NB and NNB, we show that consumers respond more aggressively to price changes for non-nutrition- benefited products than for nutrition-benefited ones. Nutrition-benefited products therefore have lower price elasticity than their non-nutrition-benefited counterparts; hence, retailers can charge a premium for nutritional benefits. According to marketing literature [52,61], a higher price can be charged for a product with strong brand equity than for a weaker brand. Therefore, the finding suggests that nutritional benefits can enhance and strengthen products' brand equity, since consumers are less likely to decrease their consumption when prices rise and are more likely to purchase the brand with a price premium. Given that nutritional benefits improve consumers' brand valuations and perceptions and thus strengthen brand equity, which is measured from "customer-based sources" [53], 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, nutritional benefits, improves consumers' healthy consumption has not yet been settled. Our third set of findings offers a novel contribution to studies in marketing and nutrition labeling which have so far failed to accept the fact that added nutritional benefits have the power to alter consumers' demand patterns. Consideration only of whether nutritional benefits influence consumers' product choice remains on the periphery of this debate because it does not sufficiently address the comprehensive impacts of nutritional benefits. The findings show that consumers exert higher function values to gains than losses for processed healthy NB and lower function values to losses than gains for unhealthy NB, suggesting a desirable demand pattern towards NB. This lends support to the view that nutritional labels function to remind consumers to consider health motives, and thus increase their consumption of healthy food [45,62]. Moreover, it highlights the danger of seeking empirical findings based on one or two product categories, since the direct impact of nutritional benefits may vary among products. Inconclusive findings may indicate that nutritional benefits have insignificant influence on product evaluations or purchase intentions [63]. This study contributes to the body of marketing literature that has sought to unravel the web of contradictory findings relating to the impact of nutritional benefits on food consumption through finding desirable demand patterns for NB when taking price changes into account.

Managerial implications

From the perspective of public policymakers, our findings shed new light on the effectiveness of economic intervention tools. 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 processed healthy food, lowering prices of processed healthy food will attract greater demand than expected. Hence, subsidizing processed healthy food production is effective in increasing the proportion of processed healthy food in consumers' baskets, thereby indirectly decreasing unhealthy food consumption. Consumers' demand response sensitivity is reduced by the presence of nutrition claims; hence, the demand for nutrition-benefited healthy food will not increase as much as expected. Therefore, economic subsidizing tools are less effective for healthy NB food than for healthy NNB food.

From the perspective of marketing practitioners, these findings reveal the value of investing in producing more nutritional tasty food. Consumers' demand response is less sensitive for nutrition-benefited food than for non-nutrition-benefited food. Hence, nutrition- benefited food has greater potential for food marketers to extract consumer surplus than expected. For unhealthy food manufacturers, developing healthier options in their existing product lines is not only profitable but also strategically important to strengthen the brand reputation by valuing consumers' welfare.

For healthy food manufacturers, it is important to develop healthier options in existing product lines, and product development can be focused on developing palatability to counteract consumers' negative sensory perceptions about healthy food. Furthermore, 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 processed 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 1.

Limitations and Directions for Future Research

Some limitations of this study also 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 establish whether variations exist. Additionally, the findings could be compared across both developed countries (e.g. France, US) and developing countries with epidemic levels of obesity (e.g. Chile, Mexico), to determine whether the impacts of nutrition claims on consumer demand patterns are constant in these different contexts.

Moreover, the study does not take into account possible different responses to various nutrition claims. For instance, consumers may have different responses to "low" versus "reduced", "sugar" versus "fat", because different types of nutrition claim and different wording flagged up in nutrition claims may affect consumers' perception and evaluation of the healthiness level of the products [64,65]. In addition, asymmetric demand patterns may differ across consumers who are more or less sceptical of the associated benefits conveyed by nutrition

Dependent variable: Logarithms quantity of demand														
	Processed Healthy Food Categories Coefficients Estimate (SE)						Unhealthy Food Categories Coefficients Estimate (SE)							
Independent Variables	Milk		Fruit Juice		Yoghurt		White Bread		Biscuits		Crisps		Cream	
Price remained same (as base)														
Nutritional benefit	-0.04**	-0.01	-0.26**	-0.02	-0.05**	-0.01	0.21**	-0.04	-0.20**	-0.02	0.33**	-0.05	-0.37**	-0.04
Brand type-no brand/budget store brand (as base)														
Brand type - standard store brand	-0.805**	-0.005	0.38**	-0.03	0.31**	-0.01	0.08**	0	0.47**	-0.01	0.50**	-0.02	0.57*	-0.26
Brand type - national brand	N/A	0.69**	-0.03	0.77**	-0.01	0.50**	0	0.73**	-0.01	0.73**	-0.02	0.25	-0.26	
Store type –other store (as base)														
Store type –convenience store	0.46**	-0.03	1.06**	-0.17	-0.05	-0.13	-0.03	-0.02	-0.01	-0.06	0.07	-0.05	0.034	-0.157
Store type –discount store	0.72**	-0.03	1.03**	-0.17	-0.1	-0.13	-0.12**	-0.02	0.11+	-0.06	0.19**	-0.05	-0.084	-0.154
Store type –grocery store	0.92**	-0.03	1.01**	-0.17	-0.01	-0.13	0.02	-0.02	0.17**	-0.06	0.32**	-0.05	0.144	-0.152
Store type –drug store	-0.84+	-0.44	0.98**	-0.18	0.47*	-0.23	-0.13	-0.16	0.06	-0.08	-0.34**	-0.08	N/A	
Shopping frequency	-0.01**	0	-0.01**	0	-0.01**	0	-0.01**	0	-0.01**	0	-0.01**	0	0.01	-0.01
Brand loyalty	-0.06**	0	-0.04**	-0.01	-0.02**	0	-0.02**	0	-0.01**	0	0.01+	-0.01	0.02+	-0.01
Social class 1 (as base)														
Social class 2	0.17**	-0.03	0.26+	-0.15	-0.06*	-0.02	0.06*	-0.03	0.11+	-0.06	0	-0.05	-0.03	-0.1
Social class 3	0.14**	-0.03	0.65**	-0.14	-0.05+	-0.02	0.03	-0.03	0	-0.06	0	-0.05	0.05	-0.09
Social class 4	0.24**	-0.03	0.26+	-0.15	-0.07**	-0.02	0.01	-0.03	0.07	-0.06	0.04	-0.05	0.03	-0.09
Social class 5	0.20**	-0.03	0.31*	-0.15	-0.10**	-0.02	0.04+	-0.03	-0.01	-0.06	0.08+	-0.05	0.04	-0.09
Social class 6	0.24**	-0.03	0.39*	-0.16	-0.10**	-0.02	0	-0.03	-0.03	-0.06	0.04	-0.05	0.03	-0.09
Age band control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household size control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	-0.27**	-0.05	-1.32**	-0.23	-0.49**	-0.14	-0.32**	-0.03	-1.10**	-0.08	-0.94**	-0.07	-0.63+	-0.33
N	50696		4584		33805		55455		30730		13374		2588	
Chi-square	68864.367***		5809.793***		54505.220***		1.60e+05***		93828.366***		62510.614***		7840.072***	
p-value for chi	0.000		0.000		0.000		0.000		0.000		0.000		0.000	

Standard error in parentheses + $p<0.10$ * $p<0.05$ ** $p<0.01$ Notes: N.A. =not applicable.

Table 6: Random-effects regression analysis results for quantity purchased: Model 3.

claims; and consumers' demand patterns can be affected if consumers generate "halo effects" [8] towards products with nutritional benefits [10] see example from [66].

Thirdly, the study focuses on the asymmetric patterns across nutrition-benefited products and non-nutrition-benefited products, whereas the "healthy" claim is not considered due to sample limitations. Given that nutrition and health claims are considered to be strong marketing incentives for the processed foods industry [67], the co-presence of nutrition and health claims may affect consumers' demand patterns, and future studies could explore whether differences occur between consumers' demand patterns for nutrition-benefited products only, and for 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.

Furthermore, the study excluded the purchases of light product buyers who did not purchase the same product category often (e.g. once per month). Light buyers make up a considerable, even if not the largest, segment of buyers. Further research could be conducted to include light product buyers in the observation and to compare the demand patterns across heavy brand buyers and light brand buyers.

Fifthly, our findings have not ruled out price promotion effects. As Fok et al. [13] pointed out, consumers' immediate response to price promotion is far greater than to regular price changes. The dummy variable of *Coupon* allows us to identify whether a consumer participates in coupon usage, but does not enable us to distinguish price promotion (or bulk saving). This limitation invites further study to re-examine the asymmetric demand pattern across NB and NNB with and without price promotion effects. Moreover, observing whether a purchase is made under price promotion helps researchers to identify whether a price increase is due to a brand returning to a regular price after a price promotion. Different triggers of price change may lead to different depths of response. Hence, it is worthwhile to observe asymmetric demand pattern across scenarios of price change due to different reasons: (1) price decrease due to downward-adjusting regular price; (2) price decrease due to price promotion; (3) price increase due to upward-adjusting regular price; (4) price increase due to returning to regular price after a price promotion [68-70].

Finally, 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 stores vs. large supermarkets).

Notes

1. The healthiness score of low-fat potato chips is 2.36 and regular potato chips is 1.47, where score 1 refers to the least healthy and 6 the most healthy food.
2. Processed healthy and unhealthy product categories are listed in Table 2.
3. The definitions of healthy and unhealthy foods are given by the UK Food Standards Agency [68] Product categories used in this study are generally considered as healthy (e.g. yoghurt) and

unhealthy (e.g. potato chips) in the existing literature, such as the survey study from [5]. See Measures section.

4. 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. Moreover, data points from households that purchased less than 12 times for each product category were dropped from the analysis dataset. Hence, the sample size was reduced from 0.8+ million to 0.7+ million.

5. 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 analysis.

6. The definition of healthy/unhealthy food has been given in the introduction. A full list of brands in the sample is available upon request.

7. Using age and household size as ratio variables in the models give us the same results as using age band and household size band as categorical variables in the models.

8. "Halo effect" refers to consumers' rating the product higher on other health attributes not mentioned in the claims. For example, consumers exhibit a halo effect for low-fat yoghurt if they perceive that this product is low in fat and also low in calories.

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