Use of Supermarket Scanner Data to Measure Bread Consumption and Nutrition Choice in Scotland

Cesar Revoredo-Giha, Chrysa Lamprinopoulou, Luiza Toma, Beata Kupiec-Teahan, Philip Leat and Luca Cacciolatti

Food Marketing Research - Land Economy and Environment Research Group,
Scottish Agricultural College (SAC),
King's Buildings, West Mains Road, Edinburgh EH9 3JG, UK,
Phone: 44-(0)131 535 4344, Fax:44-(0)131 667 2601,
E-mails: Cesar.Revoredo@sac.ac.uk, Chrysa.Lamprinopoulou@sac.ac.uk
Luisa.Toma@sac.ac.uk, Beata.Kupiec@sac.ac.uk
Philip.Leat@sac.ac.uk, Luca.Cacciolatti@sac.ac.uk

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Abstract

The recent rise in food prices has increased the concern about the choice of a healthy food basket, especially in the context of the discussion around the formulation of a National Food Policy for Scotland. This concern has brought back the interest in the price and expenditure demand systems as they provide information about consumers' food decisions. The paper focuses on the consumption of brown and white bread, as they are the most typical ways of cereals use in the UK and nutritionists recommend the consumption of wholemeal or brown bread in contraposition to white bread as part of an appropriate diet due to its health benefits. This paper aims to answer whether changes in bread prices affect the quantity and composition of the Scottish demand for bread, and whether the latter has been the same for different regions and socioeconomic groups. We used supermarket scanner data to estimate three demand systems and compute their elasticities. All the models showed statistically significant own price and expenditure elasticities. After simulating an increase in all the bread prices we found that brown bread consumption decreases more than white bread just the opposite to what is recommended by the nutritionists.

Keywords: Bread consumption models; Scotland; Food prices.

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I. Introduction

All over the world there is a growing concern about the increase in food prices and how this may affect the access to and affordability of food, and, ultimately, consumers' well being. Recent official figures for UK inflation (ONS, 2008b) indicate that the largest contribution to the change in the consumer price index (CPI) over the past year comes from the food and non-alcoholic beverages category. Although traditionally a category with prices growing at a rate below the average for all the items in the economy, bread inflation since January 2005 has grown above the overall inflation following the trend in the price of cereals. Thus, whilst the retail price index (RPI) for all the items has grown by 13 per cent between January 2005 and September 2008, the RPI for bread has grown by 33 per cent over the same period. Furthermore, if one considers specific average prices, the price of the white loaf, sliced, 800 grams has grown by 102 per cent and the wholemeal loaf, sliced, 800 grams, by 58 per cent during the same period (ONS, 2008b).

The choice of bread prices and consumption as the subject of study in this paper is associated, first, to the fact that bread represents a significant almost 5 per cent of the household expenditure on food and non-alcoholic drinks. Furthermore, according to the Flour Advisory Bureau (2008), bread remains one of the UK's favourite foods, with 99 per cent of households buying bread, of which white bread accounts for 70 per cent of the consumption. It should also be noted the increasing importance of the so called “Premium bread”. According to the Flour Advisory Bureau, when introduced in the early 1990s, premium bread proved extremely successful, and currently accounts for around 21 per cent of the plant white bread market. This was reinforced by the launch in late 1998 of premium brown and wholemeal loaves.

The second reason for choosing to study bread is because nutritionists’ recommendations make a clear distinction between the consumption of wholemeal or brown bread in contraposition to white bread as part of an appropriate diet (e.g., Mooney, 1990). Furthermore, the latter is part of the recommendation that regular consumption of wholegrain foods has been associated with a reduction in the incidence of cardiovascular disease and diabetes, reductions in cancer mortality and an overall reduction in premature death (Lang and Jebb, 2003).

The main motivation behind the paper is the current discussion around the formulation of a National Food Policy for Scotland. One of the aspects of the discussion is related to food education – supporting consumers and the food and drink industry to make healthier and more environmentally sustainable choices. Thus, analysing how consumers respond to prices, choosing or not healthy options, contributes to providing background information for the discussion.

The purpose of this paper is to estimate the effect that changes in bread prices may have had on the Scottish consumption of the different types of breads (e.g., white versus

wholemeal bread) through the estimation of different demand system for different types of breads.

It is important to note that the available consumer surveys for the estimation of demand systems are UK based with a small number of observations for Scotland (e.g., Expenditure and Food Survey). This situation makes difficult to analyse the consumption behaviour of regions and socioeconomic groups within the country. Due to this reason data from supermarket scanners was used in this study.

Supermarket scanners information is a really promising data source for demand analysis, as it allows studying a number of different issues not possible with conventional consumer surveys. Thus, according to Cotterill (1994), supermarket scanner data have been particularly useful in demand modelling and empirical analysis of price, advertising retailer push, and consumer pull market strategies at the brand as well as product category or industry level. It is important also to point out that as source of consumption, supermarket data is not perfect as it does not include all the consumption outside the household, which has grown overtime. Furthermore, according to the Flour Advisory Bureau the consumption of bread, e.g., in the form of sandwiches, is a category that has grown significantly in the last years in the UK.

The structure of the paper is as follows: first, an overview of the benefits of the wholegrain food consumption is sketched. Second, the methodology is presented, comprising a description of the data used and the estimated models, which are three: the double log demand model (Stone, 1954), the Rotterdam demand system (Theil, 1965 and Barten, 1967) and the Linear Approximation of the Almost Ideal Demand System (LA/AIDS) (Deaton and Muellbauer, 1981). This is followed by a discussion of the results and their implications in terms of nutrition.

II. Bread consumption and nutrition

Whole-wheat flour is produced by the whole cereal grains, which comprise three structural layers: the endosperm, the bran and the germ (Anderson et al., 2000). The bran constitutes the outer “shell” of the grain that protects the germ (the inner layer) and the endosperm, the middle layer, which is predominantly carbohydrate and accounts for approximately 80 per cent of the grain.

During the milling process, refined grains retain only the starchy endosperm. Products of refined cereal grains such as white flour, include neither the bran which is rich in B vitamins, unsaturated fatty acids, phytochemicals such as flavonoids, indoles, phyto-oestrogens and fibre (Southgate, 1995), nor the germ that has abundance of minerals such as Fe, Zn, Mg, Ca, S and Zn as well as the antioxidant vitamin E (Sidhu et al., 2007). The removal of bran and germ results in a substantial loss of important nutrients, therefore whole grain products are nutritionally superior to the refined grain ones. Wholemeal and brown bread belong to the most commonly consumed sources of wholegrain in the Western cultures, together with breakfast cereals, oatmeal, crackers, brown rice and popcorn (Richardson, 2000).

The lack of a uniform definition of whole grain foods and the inconsistency in estimates of serving sizes hinder the comparison between different studies on whole grain consumption (Lang and Jebb, 2003). According to the US Food and Drug Administration (FDA), the wholegrain claim can be only related to foods that contain at least 51 per cent wholegrain ingredients such as wholegrain wheat, maize, oats and rice, by weight per reference amount customarily consumed (RACC) per day (Pape et al., 1999). The food must include all portions of the grain kernel as naturally occurring and at least 16g wholegrain/RACC. Companies in the UK follow the same definition for wholegrain products in order to be harmonised with the US law. In contrast to the European countries, the US have specified exact quantities of whole grain foods for dietary recommendations, setting the target of at least three servings per day as a nutrition objective for 2010 (US Department of Health and Human Services, 2000).

Since wholegrain foods contain increased proportion of fibres that are not digested, they have lower energy content, which can lead to reduced energy intake compared to refined grains. Moreover, the consumption of dietary fibres promotes satiation and reduces the return of hunger, illustrating their impact on the maintenance of body weight. Fibres can also interfere with the secretion of gut hormones that are related to the metabolism of glucose and involved into satiety (Koch-Banerjee and Rimm, 2003). Water-soluble fibres are subject to fermentation in the small intestine yielding end products which may have health-protective action. Non-soluble fibres have hypdrophilic properties that increase the bulk of intestinal contents and decrease the transit time, reducing constipation and the risk not only of colon cancer but also of neoplasms across the whole intestinal track.

Despite the aforementioned health benefits, the consumption of wholegrains remains below the dietary recommendation of three servings per day in both the US and UK (Lang and Jebb, 2003). Wholemeal and brown bread contribute over 40 per cent to whole grain intake for British adults (Land et al., 2001), followed by wholegrain breakfast cereals.

Several studies have been performed to identify demographic variables related to high consumption of wholegrain foods. Particularly, the consumption was found to increase with age, income and educational level in the US and UK (Adams and Engstrom, 2000). Men seem to consume more wholegrain foods than women, but this may be due to the overall larger quantity of food consumed by men (Jacobs et al., 2001). North American and British consumers of wholegrain foods were likely to be also associated with other health living habits such as non-smoking, regular exercise and consumption of fruit and vegetables (Johansson et al., 1999; Adams and Engstrom, 2000). Qualitative research conducted by Adams and Engstrom (2000) in the US indicated as reasons for the low consumption of wholegrain foods the difficulty to identify, prepare and cook these particular products, as well as the dry and bitter taste of wholegrain breads.

In Scotland, Wrieden et al. (2006) evaluated, using the Expenditure and Food Survey and the National Diet and Nutrition Survey, how close Scottish consumers were to the nutritional targets set by the Scottish Government by analysing the mentioned survey data

by Scottish Index of Multiple Deprivation[1] (SIMD) and rural and urban population. Their results showed that the least deprived quintile had the highest weekly consumption of brown/wholemeal bread and breakfast cereals. This result was also found for the Scottish rural population in comparison to the urban population.

III. Methodology and results

The purpose of this section is to present the empirical work carried on. It starts with a description of the data used, followed by the models estimated and ends with a presentation of the results and discussion.

III.1 Data

The information used in the paper, i.e., Scottish prices and purchases, was extracted from the dunnhumby database, which provides data on the evolution of weekly purchases by representative supermarket shoppers in the UK.

The data consisted of information on the value of bread purchases in GB pounds, number of purchased units, number of customers and prices per unit in GB pounds, all variables at product level (a total of 244 bread products). Two main bread categories were considered: brown (e.g., brown, wholemeal, multigrain) and white bread due to the requirement of studying their reaction to prices and whether their consumption is somewhat related (i.e., presence of a substitution or complementarity effect). These categories were further subdivided into non-premium and premium. Therefore a total of four categories were considered in the analysis, namely: brown bread, premium brown bread, white bread and premium white bread.

In order to aggregate the products into the four aforementioned categories, the quantities purchased were transformed into grams using the weight information provided for each product. Furthermore, the quantities purchased were expressed as quantities per customer. Prices were also re-expressed as GB pounds per gram.

As regards the data availability, it consisted of 104 points of weekly data starting the week of the 9th of October 2006 and ending the 29th of September 2008 for three Scottish TV advertising regions (i.e., Borders, Central and North Scotland) and by ten socio-economic groupings (i.e., using CAMEO-UK, a geo-demographic classification system for assessing the socio-economic and demographic characteristics of residential neighbourhoods). Due to the sparse information for some of the socioeconomic groups, the ten groups were merged into three groups (Group A=affluent group, Group B=middle group, and Group C=poorer group). The descriptive statistics of the data are presented in table 1.

[1] A geo-demographic index constructed by the Scottish Government used to measure the level of deprivation according to a number of indicators collected by for different areas.

Table 1: Descriptive statistics 1/2/

	Borders Groups 3/				Central Scotland Groups 3/				Northern Scotland Groups 3/				Scottish Groups 3/			
	A	B	C	All	A	B	C	All	A	B	C	All	A	B	C	All
Weekly bread quantities (grams)																
Brown	1,001.6	968.1	907.5	957.0	884.3	880.2	867.1	875.8	969.0	901.1	915.2	943.9	932.8	898.8	883.0	906.7
Std. Dev.	45.2	48.1	38.7	31.8	24.6	28.1	25.1	22.5	30.8	38.6	33.5	27.9	25.4	25.6	25.4	23.5
Min	915.1	857.4	819.6	878.9	818.7	825.5	818.9	830.4	910.4	821.4	832.2	876.9	870.4	836.7	837.3	850.8
Max.	1,100.0	1,100.4	1,007.0	1,034.8	976.2	998.8	949.9	968.7	1,041.7	981.1	1,017.2	1,020.0	1,015.4	988.2	958.0	986.9
Premium brown	751.7	658.1	678.8	705.9	689.3	671.9	648.1	670.3	723.5	693.2	672.3	702.0	712.7	677.2	659.7	688.5
Std. Dev.	42.0	50.0	47.0	36.2	35.1	38.7	34.5	31.8	31.9	43.1	38.2	30.8	29.8	33.5	34.2	29.7
Min	666.0	572.8	577.8	628.9	630.3	600.0	597.0	629.1	666.3	616.1	619.1	660.7	664.3	629.0	617.3	649.6
Max.	861.2	803.5	838.3	815.0	808.5	815.5	775.2	784.4	812.0	836.5	821.6	802.7	801.7	800.0	796.3	789.8
White	1,182.3	1,103.1	1,098.7	1,128.6	1,007.2	979.8	1,011.4	1,004.6	1,060.0	1,019.0	1,025.1	1,042.2	1,048.4	1,005.4	1,023.5	1,029.2
Std. Dev.	51.6	45.6	47.0	41.9	22.7	20.8	23.7	20.9	28.0	31.2	28.1	24.1	25.1	21.3	24.5	22.5
Min	1,052.6	987.4	1,012.0	1,034.2	945.0	910.3	944.5	938.1	1,001.0	945.2	976.4	985.2	983.5	934.7	960.5	964.0
Max.	1,310.9	1,203.4	1,229.1	1,238.4	1,082.9	1,034.7	1,113.7	1,090.1	1,161.2	1,099.0	1,136.1	1,141.9	1,137.9	1,062.7	1,130.5	1,121.8
Premium white	723.7	666.5	673.8	693.3	641.7	658.4	634.6	642.4	698.2	667.8	666.7	685.0	678.4	661.5	649.0	664.5
Std. Dev.	36.2	46.6	36.6	30.7	19.7	26.6	21.6	19.5	28.6	27.1	27.5	24.6	23.1	23.6	21.6	21.3
Min	646.3	554.1	606.3	641.1	605.9	609.0	582.6	612.0	637.3	616.1	616.3	646.2	630.6	625.7	612.4	633.4
Max.	844.6	828.6	827.3	809.4	702.3	740.9	695.1	702.9	799.2	775.9	752.4	759.9	750.1	734.8	714.4	733.1
Weekly bread prices (pence/10 gr.)																
Brown	1.10	1.09	1.09	1.09	1.13	1.13	1.12	1.12	1.08	1.12	1.08	1.09	1.11	1.12	1.11	1.11
Std. Dev.	0.11	0.18	0.09	0.10	0.10	0.18	0.11	0.11	0.10	0.17	0.11	0.10	0.10	0.17	0.10	0.10
Min	0.90	0.94	0.90	0.91	0.93	0.91	0.92	0.93	0.91	0.86	0.88	0.91	0.92	0.90	0.92	0.92
Max.	1.30	1.61	1.26	1.27	1.30	1.53	1.31	1.31	1.27	1.57	1.28	1.27	1.28	1.52	1.29	1.28
Premium brown	1.22	1.26	1.21	1.23	1.24	1.25	1.22	1.24	1.24	1.24	1.24	1.25	1.24	1.25	1.23	1.24
Std. Dev.	0.17	0.18	0.19	0.18	0.18	0.18	0.17	0.18	0.18	0.17	0.18	0.17	0.18	0.17	0.18	0.18
Min	0.93	0.94	0.82	0.89	0.91	0.91	0.90	0.91	0.91	0.86	0.90	0.91	0.92	0.90	0.90	0.91
Max.	1.52	1.61	1.56	1.53	1.54	1.53	1.53	1.52	1.53	1.57	1.52	1.52	1.52	1.52	1.51	1.51
White	1.08	1.08	1.07	1.08	1.10	1.11	1.08	1.09	1.07	1.09	1.05	1.06	1.08	1.10	1.07	1.08
Std. Dev.	0.12	0.12	0.11	0.12	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.11	0.11	0.12	0.12	0.12
Min	0.86	0.89	0.89	0.88	0.92	0.94	0.91	0.93	0.89	0.91	0.86	0.88	0.91	0.93	0.90	0.91
Max.	1.31	1.31	1.31	1.31	1.33	1.34	1.33	1.33	1.29	1.32	1.27	1.29	1.31	1.33	1.31	1.32
Premium white	1.27	1.29	1.26	1.27	1.32	1.30	1.25	1.29	1.28	1.30	1.28	1.29	1.30	1.30	1.26	1.29
Std. Dev.	0.14	0.15	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.15	0.15	0.15	0.15	0.15
Min	1.04	1.01	1.04	1.03	1.11	1.08	1.04	1.08	1.05	1.07	1.02	1.05	1.08	1.09	1.04	1.07
Max.	1.54	1.63	1.60	1.56	1.58	1.55	1.50	1.53	1.54	1.61	1.56	1.54	1.55	1.53	1.52	1.53

Source: Own elaboration based on dunnhumby data.
Notes:
1/ The quantities are per customer.
2/ The first row for each product is the mean of the variable.
3/ Group A= affluent, group B=middle, group C=poorer.

III.2 Models

Three demand systems were estimated in the paper: the double log demand system, the Rotterdam demand system and the so-called linear approximate of the Almost Ideal Demand System (LA/AIDS). This section presents the models briefly as they are well-known models in the economic literature and extensive information about their characteristics can be found elsewhere (e.g., Deaton and Muellbauer, 1991).

The choice of these three models was due to the fact that they have been previously used in the literature of demand systems using supermarket scanner data. Thus, the double log model was used, for instance, by Capps (1989) in his study of demand for meat products and has the advantage that its parameters measure directly the price and expenditure elasticities. The demand equation to estimate is given by (1), where k is the number of sub-categories, P_j denotes the price of the j sub-category (e.g., brown bread), Q_i is the quantity purchased of i, E is the expenditure in the category (e.g., total expenditure in bread), the α's are the model parameters (i.e., the elasticities) and μ_i is a random error term (the sub-index "t" associated with time has been dropped to simplify the expressions).

$$(1) \qquad \log(Q_i) = \alpha_0 + \sum_{j=1}^{k} \alpha_j \cdot \log(P_j) + \alpha_{k+1} \cdot \log(E) + \mu_i$$

The Rotterdam demand system was used, for instance, by Capps and Love (2002) to study the demand for chilled and self stable fruit juices and drinks.[2] The equation for each sub-category within the demand system is given by equation (2):

$$(2) \qquad \omega_i \cdot d\log(Q_i) = \alpha_i \left(d\log(E) - \sum_{i=1}^{k} \omega_k \cdot d\log(P_k) \right) + \sum_{j=1}^{k} \alpha_{ij} \cdot d\log(P_j) + \mu_i$$

Where $d\log(\bullet)$ represents the differential of the logarithm, approximated (for any variable x) by $d\log(x_t) = \log(x_t) - \log(x_{t-1})$ and $\omega_k = \frac{P_k \cdot Q_k}{E}$ is the expenditure share of the sub-category within the category and the other variables and parameters have already been defined.

In order to be consistent with the theory, the system has to satisfy the following constraints (in addition to the negative semi-definitiveness of the Hessian matrix on prices):

[2] Other applications are Nayga and Capps (1994) on the demand for meat products; Seo and Capps (1997) and Capps, Seo and Nichols (1997), both papers on the demand for spaghetti sauces.

$$(3)\qquad \begin{gathered} \sum_{i=1}^{k}\alpha_i = 1;\ \sum_{i=1}^{k}\alpha_{ij} = 0\ (\text{Adding}-\text{up}) \\ \sum_{j=1}^{k}\alpha_{ij} = 0\ (\text{Homogeneity}) \\ \alpha_{ij} = \alpha_{ji}\ (\text{Symmetry}) \end{gathered}$$

The Marshallian (i.e., uncompensated) elasticities in the Rotterdam demand system are given by (4), where ε_{ij} is the own and cross price elasticity and η_i is the expenditure elasticity.

$$(4)\qquad \begin{gathered} \varepsilon_{ij} = \frac{(\alpha_{ij} - \omega_j\alpha_i)}{\omega_i} \\ \eta_i = \frac{\alpha_i}{\omega_i} \end{gathered}$$

The LA/AIDS model can be found, for instance, in Cotterill (1994) applied to the market of regular carbonated soft drinks[3]. The equation for each sub-category within the demand system is given by (5):

$$(5)\qquad \omega_i = \alpha_0 + \sum_{j=1}^{k}\alpha_{ij}\cdot\log(P_j) + \alpha_{ik+1}\cdot\log\left(\frac{E}{P}\right) + \mu_i$$

Where P is a geometric price index (Stone price index) defined as $\log(P) = \sum_{i=1}^{k}\omega_i\cdot\log(P_i)$. Similar to the Rotterdam demand system, the LA/AIDS needs to satisfy a number of constraints in order to be consistent with the economic theory. These are given in (6):

$$(6)\qquad \begin{gathered} \sum_{i=1}^{k}\alpha_{ik+1} = 1;\ \sum_{i=1}^{k}\alpha_{ij} = 0\ (\text{Adding}-\text{up}) \\ \sum_{j=1}^{k}\alpha_{ij} = 0\ (\text{Homogeneity}) \\ \alpha_{ij} = \alpha_{ji}\ (\text{Symmetry}) \end{gathered}$$

The Marshallian elasticities are given by ε_{ii} (own price elasticity), ε_{ij} (cross price elasticity and η_i (expenditure elasticity) in (7):

$$(7)\qquad \begin{gathered} \varepsilon_{ii} = -1 + \frac{\alpha_{ii}}{\omega_i} - \alpha_{ik+1} \\ \varepsilon_{ij} = \frac{\alpha_{ij}}{\omega_i} - \alpha_{ik+1}\frac{\omega_j}{\omega_i} \\ \eta_i = 1 + \frac{\alpha_{ik+1}}{\omega_i} \end{gathered}$$

[3] Also see, Capps, Church and Love (2002) applied to the demand for spaghetti sauces.

The previously described models were estimated using Iterative Seemingly Unrelated Regressions (SURE). Whilst in the case of the double log demand system no theoretical constraints were imposed (such as in Capps, 1989), the Rotterdam systems and the LA/AIDS were estimated imposing the theoretical constraints described in the previous section. As it is well known, it is not possible to estimate at the same time the four equations that comprise the Rotterdam and LA/AIDS model and one of the equations has to be dropped. In all the estimations, the equations for premium white bread were not considered in the estimation and their parameters recovered using the theoretical constraints. All the estimations were carried on with the econometric software Shazam version 10.

III.3 Results and discussion

Although the specific results from the models are of interest and they are available from the authors upon request, for brevity purposes we only present the estimated Marshallian or uncompensated elasticities and their degree of significance. These are shown in Table 2, which gives the elasticities for the three Scottish regions and for Scotland, and within these regions, for each socioeconomic group.

All the estimated models produced own prices elasticities for all the regions and socio-economic groups that were not only statistically significant at 1 per cent but also with the correct sign (i.e., negative sign). Moreover, most of the expenditure elasticities were significant and positive. However, the previous statement does not mean that all the models showed similar results. At the level of Scotland, on the one hand, the double log and the Rotterdam models showed similar own price elasticities, which were lower than in absolute value (i.e., price inelastic) for all the bread categories. On the other hand, the elasticities from the LA/AIDS model were mixed. It showed that consumption of brown bread and premium white bread was elastic, whilst the consumption of premium brown bread and white bread was inelastic. The own price elasticity for premium white bread was -3.5, indicating high sensitivity to prices.

The expenditure elasticities for Scotland also differed by model, with the double log system showing all the elasticities lower than one, Rotterdam's elasticities equal to one or close to it and the LA/AIDS' ones above one, especially in the case of white premium bread, which showed an elasticity of two.

The results by region (i.e., groups in Table 2 identified as "altogether") were similar to those observed for Scotland, although some differences appear. In term of similarities, the own price elasticities of the double log model and Rotterdam were all below the unity, indicating that the consumption of all the categories was price inelastic. The elasticity for premium white bread in all the regions for the LA/AIDS model was quite high (between 2.8 and 3.4). In addition, the expenditure elasticities from the three models were below, around and most of the time, above the unity for the double log, Rotterdam and LA/AIDS models, respectively. In terms of differences, the own price elasticities for brown bread were slightly below one for Borders and Northern Scotland and above one for Central Scotland.

In terms of the results by socioeconomic groups (i.e., results for groups A, B, and C in the Scotland panel of Table 2), these were quite similar to those observed for Scotland. The similarity in terms of own price elasticities between double log and the Rotterdam models held by socioeconomic group. The LA/AIDS model predicted that brown bread own price elasticity was around one, whilst premium brown and white bread were price inelastic and the own price elasticity for premium white was highly price elastic. In addition, the relationship between the expenditure elasticity for the three models also held as in the Scottish case.

The results regarding the cross-price elasticities for the different models, regions and socioeconomic groups were interesting and in some way puzzling. Many of the cross price elasticities were significant, however, in contrast with what one may have expected, they indicated that the different types of bread were complements instead of substitutes. This result is not new and can be found in Cotterill (1994) in his study of carbonated soft drinks using scanner data, who found complementary demand relationships between competing soft drinks. Furthermore, observing his Table 1 (pp. 137) one can realise that several of the cross price elasticities with negative signs were significant. He explained it by the fact that all the soft drinks are in the same aisle in supermarkets, something common with the way that bread is sold (especially if one considers bread baked in the supermarket). However, it is also possible to attribute this result to the aggregation problem, as expenditure recorded every period considers a number of different customers buying different products at the same time. If one considers this aggregate as a representative individual, then one may obtain spurious cross price elasticities (although they might be useful to predict aggregate consumption).[4]

What are the implications of the results in nutritional terms? In other terms, what is it possible to say in terms of the consumption of brown and white bread based on the estimated models? Given the difference in the elasticities obtained from the models, certainly the answer depends on which one is used.

If the double log demand system or the Rotterdam demand system were used, then the rise in price would not have any dramatic effect on the consumption of any bread category. However, if one also considers the results of the cross section elasticities, i.e., the large number of significant complement elasticities, then the effect would be greater than that predicted by the own price elasticities (note that this would also be true in the case of the LA/AIDS model as it also contains a large number of significant negative cross price elasticities). This can be observed by comparing the results from Table 2 with those from Table 3, which reports the results from a simulation of an increase by 1 per cent in all bread prices.

[4] See Deaton and Muellbauer (1991), pp. 80 about a discussion on consumption across individuals and commodities.

Table 2: Price and expenditure demand elasticity by region, geo-demographic group and demand system 1/ 2/

	Double log demand system										Rotterdam demand system										LA/AIDS									
	Brown	Sig.	Premium Brown	Sig.	White	Sig.	Premium White	Sig..	Expendi-ture	Sig.	Brown	Sig.	Premium Brown	Sig.	White	Sig.	Premium White	Sig.	Expendi-ture	Sig.	Brown	Sig.	Premium Brown	Sig.	White	Sig.	Premium White	Sig.	Expendi-ture	Sig.
Borders																														
Group A																														
Brown	-0.815	*	-0.139	*	0.121		-0.017		0.783	*	-0.716	*	-0.167	*	0.002		-0.021		0.902	*	-0.955	*	-0.298	*	-0.318		0.446		1.125	*
Premium Brown	-0.093		-0.449	*	-0.086		-0.193	*	0.760	*	-0.227		-0.570	*	-0.114		-0.092		1.003	*	-0.348	*	-0.636	*	-0.359	*	0.258		1.084	*
White	-0.077		-0.110	*	-0.656	*	-0.019		0.873	*	-0.009		-0.069		-0.762	*	-0.104		0.943	*	-0.277		-0.269	*	-1.050	*	0.460		1.136	*
Premium White	0.130		-0.027		-0.250	*	-0.657	*	0.798	*	-0.102		-0.133		-0.219	*	-0.740	*	1.193	*	-0.519		-0.628		-0.580		-3.426	*	2.072	*
Group B																														
Brown	-0.713	*	-0.134	*	0.075	*	-0.044		0.965	*	-0.744	*	-0.136		-0.033		-0.033		0.946	*	-0.910	*	-0.161		-0.103		0.083		1.091	*
Premium Brown	0.000		-0.541	*	-0.175		-0.108		0.680	*	-0.203		-0.605	*	-0.034		-0.209	*	1.052	*	-0.198		-0.643	*	-0.113		0.121		1.055	*
White	-0.044		-0.093	*	-0.605	*	-0.125	*	0.852	*	-0.058		-0.024		-0.821	*	-0.150	*	1.054	*	-0.067		-0.146		-0.814	*	0.027		0.999	*
Premium White	0.021		-0.020		-0.213		-0.593	*	0.807	*	-0.040		-0.178	*	-0.175		-0.549	*	0.942	*	-1.063		-0.899	*	-1.305	*	-2.156	*	1.922	*
Group C																														
Brown	-0.671	*	-0.127	*	0.047		-0.098		0.757	*	-0.749	*	-0.155	*	-0.068		-0.096		1.069	*	-0.843	*	-0.277	*	-0.435	*	0.131		1.424	*
Premium Brown	0.059		-0.514	*	-0.187		-0.139		0.967	*	-0.161		-0.543	*	-0.145		-0.116		0.965	*	-0.149		-0.575	*	-0.278	*	0.336		0.708	*
White	-0.183		-0.098	*	-0.477	*	-0.119	*	0.800	*	-0.024		-0.096	*	-0.705	*	-0.117	*	0.942	*	-0.382		-0.256	*	-0.972	*	0.119		1.491	*
Premium White	0.127		-0.064		-0.336	*	-0.531	*	0.777	*	-0.103		-0.127	*	-0.192		-0.612	*	1.034	*	-0.675		-0.700		-0.800		-2.465	*	2.858	*
Altogether																														
Brown	-0.690	*	-0.138	*	0.085		-0.097	*	0.827	*	-0.646	*	-0.188	*	0.004		-0.070		0.900	*	-0.838	*	-0.279	*	-0.314		0.258		1.173	*
Premium Brown	-0.035		-0.471	*	-0.146		-0.158	*	0.801	*	-0.262	*	-0.491	*	-0.132		-0.146	*	1.031	*	-0.292		-0.621	*	-0.316		0.361		0.996	*
White	-0.128		-0.110	*	-0.537	*	-0.093		0.841	*	-0.054		-0.112	*	-0.786	*	-0.166		1.119	*	-0.312		-0.288	*	-0.995	*	0.264		1.331	*
Premium White	0.115		-0.037		-0.331	*	-0.553	*	0.783	*	-0.090		-0.119	*	-0.170	*	-0.545	*	0.924	*	-0.665		-0.621		-0.715		-2.890	*	2.416	*
Central Scotland																														
Group A																														
Brown	-0.723	*	-0.117	*	0.067		-0.072		0.809	*	-0.721	*	-0.152	*	-0.216	*	-0.109	*	1.198	*	-1.110	*	-0.449	*	-0.547	*	0.481		1.626	*
Premium Brown	0.150		-0.474	*	-0.321	*	-0.163	*	0.837	*	-0.187	*	-0.599	*	-0.244	*	-0.202	*	1.232	*	-0.483	*	-0.794	*	-0.571	*	0.391		1.458	
White	-0.258	*	-0.107	*	-0.325	*	-0.175	*	0.806	*	-0.094		-0.094	*	-0.458	*	-0.169	*	0.815	*	-0.357		-0.359	*	-0.862	*	0.472		1.106	*
Premium White	0.081		-0.097	*	-0.379	*	-0.401	*	0.830	*	-0.018		-0.101		-0.210	*	-0.449	*	0.777	*	-0.097		-0.211		-0.270		-3.574	*	1.515	*
Group B																														
Brown	-0.711	*	-0.090	*	0.007		-0.067		0.738	*	-0.713	*	-0.058		0.056		-0.003		0.719	*	-0.845	*	-0.328	*	-0.505	*	0.412	*	1.266	*
Premium Brown	-0.053		-0.482	*	-0.057		-0.190		0.958	*	-0.354	*	-0.676	*	-0.460	*	-0.306	*	1.795	*	-0.387		-0.715	*	-0.583	*	0.507		1.250	*
White	-0.192		-0.138	*	-0.349	*	-0.175	*	0.848	*	0.065		-2.899	*	-0.516	*	-0.111	*	0.666	*	-0.365		-0.303		-0.643	*	0.418		0.893	
Premium White	0.146		-0.070		-0.499	*	-0.386	*	0.765	*	-0.071		-0.118		-0.230	*	-0.555	*	0.974	*	-0.505		-0.490		-0.651		-3.357	*	1.549	*
Group C																														
Brown	-0.834	*	-0.108	*	0.172	*	-0.091	*	0.730	*	-0.551	*	-0.154	*	-0.184	*	-0.116	*	1.006	*	-0.994	*	-0.354	*	-0.599	*	0.291		1.655	*
Premium Brown	0.161		-0.484	*	-0.292	*	-0.173	*	0.892	*	-0.242	*	-0.463	*	-0.290	*	-0.211	*	1.206	*	-0.246		-0.665	*	-0.479	*	0.545		0.946	
White	-0.240	*	-0.122	*	-0.353	*	-0.148	*	0.836	*	-0.137	*	-0.145	*	-0.530	*	-0.094	*	0.907	*	-0.439		-0.331	*	-0.860	*	0.323		1.307	*
Premium White	0.164		-0.089	*	-0.466	*	-0.403	*	0.818	*	-0.118		-0.147	*	-0.133		-0.519	*	0.917	*	-0.381		-0.438		-0.489		-3.063	*	2.302	*
Altogether																														
Brown	-0.754	*	-0.108	*	0.095		-0.088	*	0.762	*	-0.551	*	-0.154	*	-0.222	*	-0.104	*	1.031	*	-1.015	*	-0.423	*	-0.654	*	0.424		1.668	*
Premium Brown	0.165		-0.470	*	-0.314	*	-0.175	*	0.889	*	-0.235	*	-0.531	*	-0.255	*	-0.201	*	1.222	*	-0.361		-0.714	*	-0.583	*	0.657	*	1.120	
White	-0.291	*	-0.123	*	-0.272	*	-0.177	*	0.823	*	-0.198	*	-0.148	*	-0.506	*	-0.173	*	1.024	*	-0.478	*	-0.376	*	-0.826	*	0.430		1.250	
Premium White	0.140		-0.092	*	-0.476	*	-0.370	*	0.809	*	-0.039		-0.088	*	-0.136	*	-0.447	*	0.709	*	-0.181		-0.280		-0.316		-3.491	*	2.036	*

Continues

Source: Own elaboration based on dunnhumby data.
Notes:
1/ "*" stands for statistically significant at 1 per cent.
2/ Elasticities read from left to right in the table

Table 2: Price and expenditure demand elasticity by region, geo-demographic group and demand system 1/ 2/ (cont.)

	Double log demand system										Rotterdam demand system										LA/AIDS									
	Brown	Sig.	Premium Brown	Sig.	White	Sig.	Premium White	Sig.	Expendi-ture	Sig.	Brown	Sig.	Premium Brown	Sig.	White	Sig.	Premium White	Sig.	Expendi-ture	Sig.	Brown	Sig.	Premium Brown	Sig.	White	Sig.	Premium White	Sig.	Expendi-ture	Sig.
Northern Scotland																														
Group A																														
Brown	-0.759	*	-0.137	*	0.182	*	-0.133	*	0.819	*	-0.609	*	-0.180	*	-0.095		-0.129	*	1.012	*	-0.917	*	-0.384	*	-0.368		0.337		1.332	*
Premium Brown	0.142		-0.435	*	-0.416	*	-0.095		0.836	*	-0.274	*	-0.499	*	-0.314	*	-0.160	*	1.247	*	-0.419		-0.688	*	-0.459	*	0.357		1.208	*
White	-0.306	*	-0.129	*	-0.305	*	-0.122	*	0.826	*	-0.042		0.157	*	-0.513	*	-0.126	*	0.838	*	-0.223		-0.290		-0.816	*	0.447		0.882	
Premium White	0.067		-0.049		-0.371		-0.454	*	0.782	*	-0.133		-0.092		-0.189	*	-0.529	*	0.943	*	-0.572		-0.495		-0.604		-3.317	*	1.555	*
Group B																														
Brown	-0.700	*	-0.096	*	0.092		-0.141		0.819	*	-0.937	*	-0.138	*	-0.055		-0.157	*	1.287	*	-1.140	*	-0.379	*	-0.361		0.350		1.529	*
Premium Brown	0.226		-0.487	*	-0.386	*	-0.146		0.910	*	-0.088		-0.504	*	-0.228	*	-0.183		1.003	*	-0.350		-0.719	*	-0.292		0.517		1.162	*
White	-0.070		-0.129	*	-0.525	*	-0.136	*	0.793	*	0.104		-0.109	*	-0.582	*	-0.114	*	0.702	*	-0.171		-0.316	*	-0.846	*	0.400		0.933	*
Premium White	-0.113		-0.081	*	-0.173		-0.440	*	0.824	*	-0.119		-0.190	*	-0.245	*	-0.490	*	1.044	*	-0.436		-0.420		-0.587		-3.297	*	1.615	*
Group C																														
Brown	-0.768	*	-0.104	*	0.110		-0.091		0.763	*	-0.725	*	-0.096		-0.108		-0.136	*	1.065	*	-0.946	*	-0.339	*	-0.511	*	0.223		1.573	*
Premium Brown	0.263	*	-0.491	*	-0.357	*	-0.199	*	0.953	*	-0.183	*	-0.656	*	-0.271	*	-0.211	*	1.321	*	-0.273		-0.668	*	-0.436		0.408		1.068	*
White	-0.205	*	-0.123	*	-0.433	*	-0.093		0.858	*	-0.003		-0.071		-0.562	*	-0.063		0.699	*	-0.366		-0.295		-0.825	*	0.315		1.171	*
Premium White	0.010		-0.072	*	-0.255		-0.501	*	0.742	*	-0.139		-0.133	*	-0.165	*	-0.556	*	0.993	*	-0.503		-0.526		-0.543		-2.885	*	1.997	*
Altogether																														
Brown	-0.742	*	-0.114		0.155	*	-0.148	*	0.800	*	-0.608	*	-0.142	*	-0.082		-0.161	*	0.994	*	-0.954	*	-0.401	*	-0.457	*	0.312		1.500	*
Premium Brown	0.228		-0.456	*	-0.446	*	-0.122	*	0.885	*	-0.202	*	-0.495	*	-0.268	*	-0.162	*	1.126	*	-0.365		-0.688	*	-0.397		0.480		1.094	*
White	-0.266	*	-0.130	*	-0.331	*	-0.132	*	0.833	*	-0.047		-0.156	*	-0.552	*	-0.128	*	0.882	*	-0.294		-0.328		-0.819	*	0.428		1.013	
Premium White	0.019		-0.066	*	-0.333	*	-0.430	*	0.775	*	-0.198	*	-0.139	*	-0.204	*	-0.491	*	1.031	*	-0.487		-0.419		-0.520		-3.299	*	1.791	*
Scotland																														
Group A																														
Brown	-0.739	*	-0.127	*	0.132		-0.112	*	0.809	*	-0.572	*	-0.174	*	-0.106		-0.125	*	0.977	*	-1.025	*	-0.444	*	-0.491	*	0.470		1.491	*
Premium Brown	0.085		-0.446	*	-0.319	*	-0.128	*	0.829	*	-0.231	*	-0.487	*	-0.236	*	-0.127	*	1.081	*	-0.463	*	-0.739	*	-0.520	*	0.452		1.270	*
White	-0.264	*	-0.121	*	-0.339	*	-0.139	*	0.824	*	-0.098		-0.161	*	-0.544	*	-0.180	*	0.983	*	-0.356		-0.374	*	-0.930	*	0.515		1.146	
Premium White	0.115		-0.065	*	-0.410		-0.442	*	0.805	*	-0.144	*	-0.101	*	-0.228	*	-0.493	*	0.967	*	-0.222		-0.256		-0.285		-3.668	*	1.789	*
Group B																														
Brown	-0.682	*	-0.101	*	0.041		-0.109	*	0.795	*	-0.727	*	-0.148	*	-0.074		-0.098		1.046	*	-0.980	*	-0.383	*	-0.518	*	0.425		1.456	*
Premium Brown	0.054		-0.473	*	-0.214		-0.157	*	0.905	*	-0.212	*	-0.523	*	-0.257	*	-0.185	*	1.178	*	-0.364		-0.699	*	-0.491	*	0.611		1.095	
White	-0.178	*	-0.133	*	-0.387	*	-0.161	*	0.831	*	-0.018		-0.126	*	-0.541	*	-0.176	*	0.861	*	-0.372		-0.347	*	-0.804	*	0.447		1.076	
Premium White	0.080		-0.070	*	-0.410	*	-0.406	*	0.789	*	-0.090		-0.132	*	-0.253	*	-0.476	*	0.951	*	-0.364		-0.378		-0.480		-3.500	*	1.884	*
Group C																														
Brown	-0.807	*	-0.111	*	0.148		-0.089	*	0.735	*	-0.523	*	-0.122	*	-0.186	*	-0.118	*	0.950	*	-1.001	*	-0.375		-0.647		0.295		1.728	*
Premium Brown	0.220	*	-0.483	*	-0.327	*	-0.195	*	0.931	*	-0.187	*	-0.521	*	-0.200	*	-0.188	*	1.096	*	-0.230		-0.652	*	-0.486		0.582		1.407	*
White	-0.261	*	-0.123	*	-0.352	*	-0.128	*	0.831	*	-0.194	*	-0.138	*	-0.596	*	-0.128	*	1.056	*	-0.491	*	-0.347	*	-0.905	*	0.335		0.874	
Premium White	0.144		-0.080	*	-0.430	*	-0.438	*	0.796	*	-0.126	*	-0.140	*	-0.123	*	-0.501	*	0.890	*	-0.308		-0.413		-0.388		-3.098	*	2.479	*
Altogether																														
Brown	-0.738	*	-0.115	*	0.114		-0.112	*	0.780	*	-0.539	*	-0.164	*	-0.170	*	-0.136	*	1.009	*	-1.010	*	-0.427	*	-0.587	*	0.408		1.616	*
Premium Brown	0.155		-0.458	*	-0.334	*	-0.158	*	0.883	*	-0.182	*	-0.469	*	-0.184	*	-0.125	*	0.959	*	-0.357		-0.689	*	-0.498	*	0.637	*	1.048	*
White	-0.275	*	-0.128	*	-0.310	*	-0.149	*	0.825	*	-0.171	*	-0.165	*	-0.559	*	-0.178	*	1.073	*	-0.426	*	-0.373	*	-0.876	*	0.458		1.217	*
Premium White	0.118		-0.074	*	-0.433	*	-0.414	*	0.797	*	-0.141	*	-0.119	*	-0.193	*	-0.483	*	0.935	*	-0.257		-0.312		-0.336		-3.516	*	2.073	*

Source: Own elaboration based on dunnhumby data.
Notes:
1/ "*" stands for statistically significant at 1 per cent.
2/ Elasticities read from left to right in the table

Table 3: Simulation of the total effect increase by 1 per cent in all the bread prices

	Double log demand system	Rotterdam demand system	LA/AIDS		Double log demand system	Rotterdam demand system	LA/AIDS
Borders				**Northern Scotland**			
Group A				**Group A**			
Brown	-0.954	-0.883	-1.253	Brown	-0.846	-0.918	-1.301
Premium Brown	-0.642	-0.570	-1.342	Premium Brown	-0.852	-1.247	-1.146
White	-0.765	-0.762	-1.319	White	-0.862	-0.483	-0.816
Premium White	-0.907	-0.959	-3.426	Premium White	-0.454	-0.718	-3.317
Group B				**Group B**			
Brown	-0.772	-0.744	-0.910	Brown	-0.796	-1.232	-1.519
Premium Brown	-0.541	-0.814	-0.643	Premium Brown	-0.872	-0.732	-0.719
White	-0.823	-0.972	-0.814	White	-0.790	-0.806	-1.162
Premium White	-0.593	-0.727	-4.359	Premium White	-0.522	-0.925	-3.297
Group C				**Group C**			
Brown	-0.798	-0.905	-1.555	Brown	-0.871	-0.861	-1.796
Premium Brown	-0.514	-0.543	-0.853	Premium Brown	-0.785	-1.321	-0.668
White	-0.693	-0.918	-1.228	White	-0.761	-0.562	-0.825
Premium White	-0.867	-0.739	-2.465	Premium White	-0.573	-0.853	-2.885
Altogether				**Altogether**			
Brown	-0.926	-0.834	-1.117	Brown	-0.735	-0.912	-1.813
Premium Brown	-0.628	-0.899	-0.621	Premium Brown	-1.024	-1.126	-0.688
White	-0.647	-0.899	-1.283	White	-0.859	-0.835	-0.819
Premium White	-0.884	-0.835	-2.890	Premium White	-0.829	-1.031	-3.299
Central Scotland				**Scotland**			
Group A				**Group A**			
Brown	-0.840	-1.198	-2.107	Brown	-0.979	-0.871	-1.961
Premium Brown	-0.958	-1.232	-1.848	Premium Brown	-0.892	-1.081	-1.722
White	-0.864	-0.721	-1.221	White	-0.862	-0.885	-1.305
Premium White	-0.877	-0.658	-3.574	Premium White	-0.508	-0.967	-3.668
Group B				**Group B**			
Brown	-0.801	-0.713	-1.266	Brown	-0.891	-0.874	-1.881
Premium Brown	-0.482	-1.795	-1.298	Premium Brown	-0.631	-1.178	-1.190
White	-0.662	-3.527	-0.643	White	-0.859	-0.843	-1.151
Premium White	-0.885	-0.785	-3.357	Premium White	-0.887	-0.861	-3.500
Group C				**Group C**			
Brown	-0.861	-1.006	-1.946	Brown	-1.007	-0.950	-1.001
Premium Brown	-0.950	-1.206	-1.143	Premium Brown	-0.784	-1.096	-0.652
White	-0.864	-0.907	-1.191	White	-0.863	-1.056	-1.743
Premium White	-0.959	-0.666	-3.063	Premium White	-0.947	-0.890	-3.098
Altogether				**Altogether**			
Brown	-0.950	-1.031	-2.092	Brown	-0.965	-1.008	-2.025
Premium Brown	-0.959	-1.222	-0.639	Premium Brown	-0.951	-0.959	-0.550
White	-0.863	-1.024	-1.680	White	-0.863	-1.073	-1.675
Premium White	-0.938	-0.670	-3.491	Premium White	-0.921	-0.935	-3.516

Source: Own elaboration based on dunnhumby data.

It should be noted that, in general, the double log model predicts brown bread own price elasticities that are higher than those for white bread. None of the other two models show this pattern. Moreover, the Rotterdam model shows similar elasticities for both categories.

If the model used is the LA/AIDS, the results indicate that brown bread consumption will decrease almost in the same proportion as the increase in prices (or more). Furthermore, the consumption of premium white bread will also decrease but on a higher percentage as shown in Table 3. The results for premium brown bread and white bread showed lower impact on their consumption due to a change in prices as compared with the other categories.

Overall, the results indicate that the elasticities by region and by socioeconomic groups are not too different showing approximately similar responses to the increase in prices. Also, the results indicate that consumption for both brown and white bread are quite price elastic (if both prices change) and therefore an increase in their prices may reduce their consumption, however in most of the cases with a higher decrease in brown bread, i.e., just in opposite direction to that recommended by the nutritionists.

IV. Conclusions

The purpose of this paper has been to analyse the consumption of bread in Scotland due to two reasons: first, to see the effect in the consumption of different types of breads due to rise in the price of bread, reflecting the overall increase in the price of cereals. Second, due to the fact that nutritionists recommend substituting the consumption of white bread for brown or wholemeal bread due to its health benefits.

Overall results show that although all the models report statistically significant own price and expenditure elasticities, they differ in terms of their implications. Thus, whilst according to the first two models the consumption of brown bread is price inelastic (based on their own price elasticity), according to the LA/AIDS model the demand for brown bread is price elastic. However, if one simulates an increase in all the bread prices such as the one experimented in the last three years in the UK, then, given the results which indicate that consumption for both brown and white bread are quite price elastic (almost according to all the models as shown in Table 3), and although brown and white bread will decrease, brown bread consumption will decrease more, quite the opposite to what is recommended by the nutritionists.

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