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Abstract

The recent rise in food prices has increased concern about the choice of a healthy food basket, especially in the context of the current formulation of a National Food Policy for Scotland. This concern has revived interest in food 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 forms of cereals use in the UK. Moreover, 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. The overall purpose of the paper is to measure the impact that the increase in the price of cereals during the period 2005 to 2008 would have had on the purchase of brown and white bread. This is undertaken in two stages: the first measures the effect of changes in milling wheat prices on brown and white bread prices, and the second measures the elasticities of the purchases of brown and white bread with respect to changes in their prices through the estimation of four demand systems. The results, excluding those from the static LA/AIDS that seem to high, indicate, ceteris paribus, that the increase by 72 per cent in the price of wheat produced a decrease in brown and white bread purchases in the range of 30 to 40 per cent; however, as regards the question what type of bread decreased more, the answer depends on the demand model used.

Keywords: Bread consumption models; Scotland; Food prices.

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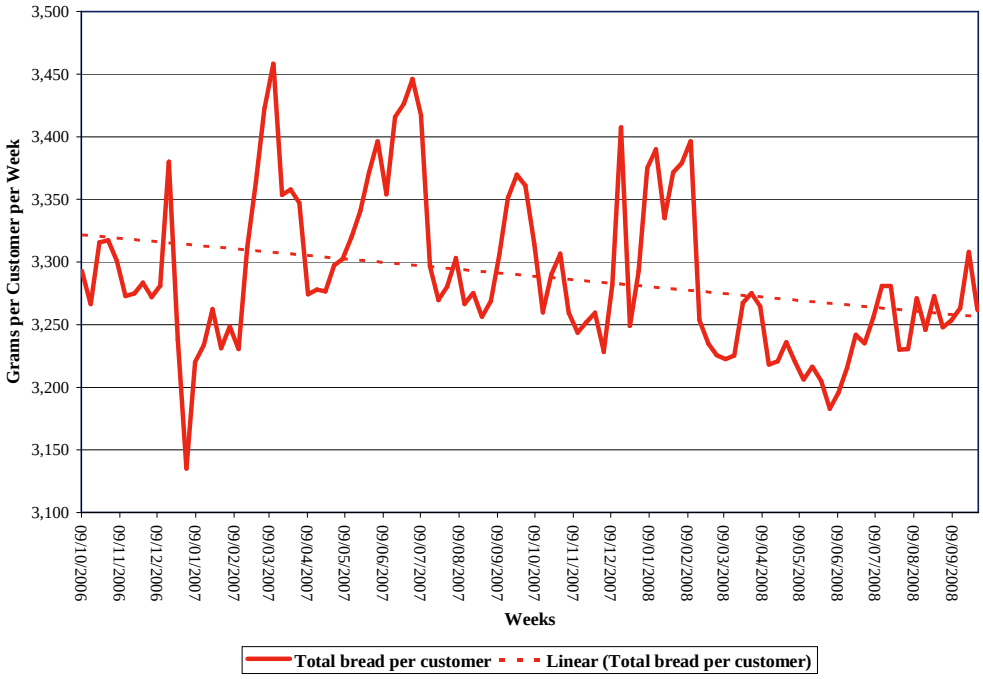
I. Introduction

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 rate following the upward trend in the price of cereals. Thus, whilst the retail price index (RPI) for all items grew by 13 per cent between January 2005 and September 2008, the RPI for bread rose by 33 per cent over the same period. Furthermore, if one considers specific average prices, the price of the 800 grams sliced white loaf has grown by 102 per cent and the 800 grams sliced wholemeal loaf by 58 per cent during the same period (ONS, 2008b). As regards total bread purchases in Scotland, Figure 1, using supermarket data, shows a decreasing trend in the purchases per customer.

Figure 1: Scotland - Total Bread Purchased per Customer, Oct 2006 to Sept 2008



Source: © dunnhumby 2009

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 part, 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 consumption. The increasing importance of so called "premium bread", should also be noted. 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 popularity 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 former is part of the recommendation that regular consumption of wholegrain foods should be encouraged as it 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 in making healthier and more environmentally sustainable choices. Thus, analysing how consumers respond to prices, choosing healthy or not healthy options, contributes to providing background information for the discussion.

The overall purpose of the paper is to measure the impact that the increase in the price of cereals during the period 2005 to 2008 has had on the purchase of brown and white bread. This is done in two stages: the first measures the effect of changes in milling wheat prices on brown and white bread prices, and the second measures the elasticities of the purchases of brown and white bread with respect to changes in their prices through the estimation of four demand systems.

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 it 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 scanner information is a really promising data source for demand analysis, as it allows the study of 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; retailer push and consumer pull promotion strategies at the brand, as well as the product category or industry level. It is important also to point out that as a source of consumption information, supermarket data is not perfect as it does not include all of the consumption outside the household, which has grown over time. 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 recent years in the UK.

The structure of the paper is as follows. First, an overview of the benefits of wholegrain food consumption is sketched. Second, the methodology is presented, comprising the estimation of the response in bread prices to change in wheat prices, description of the supermarket data used in the demand analysis and the estimated models, which are four: the double log demand model (Stone, 1954), the Rotterdam demand system (Theil, 1965 and Barten, 1967) and the static and dynamic versions of the Linear Approximation of the Almost Ideal Demand System (LA/AIDS) (Deaton and Muellbauer, 1981, Edgerton et al., 1996). 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 from the whole cereal grain, which comprises 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 an 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 whole grain in 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 whole grain claim can be only related to foods that contain at least 51 per cent whole grain ingredients, such as whole grain 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 whole grain/RACC. Companies in the UK follow the same definition for whole grain 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 whole grain foods contain an 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 in 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 properties. 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 whole grains 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 whole grain breakfast cereals as the next largest contributor.

Several studies have been performed to identify demographic variables related to high consumption of whole grain 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 whole grain foods are 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 using the Scottish Index of Multiple Deprivation[1] (SIMD) and rural and urban population data. 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 out. It starts with the analysis of the impact of wheat prices on bread prices, followed by a description of the data used in the demand analysis and the models estimated, and ends with a presentation of the results and discussion.

III.1 Impact of wheat prices on brown and white bread prices

The purpose of this section is to explore the impact that the recent increase in the price of cereals has had on the price of white and brown bread. The methodology used consisted of estimating a two price transmission

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

equation, one for each type of bread. The data used consisted of a series of monthly milling wheat prices from the Home Grown Cereals Authority (HGCA) and also monthly brown and white prices from National Statistics.

The first step of the methodology involved testing the stationarity of the data (i.e., to test the presence of unit roots in the prices of wheat, and bread). For that purpose we used the Augmented Dickey Fuller test. As is typical in averaged time-series, all the prices were found to have a unit root.

In order to reach the final error correction equations, linking the price of wheat with the price of each bread type, we started the econometric work estimating an autoregressive distributed lag model and using the general to specific methodology (Charemza and Deadman, 1997) to reduce the number of parameters in the equations. The resulting parsimonious equations were transformed into error correction forms. The equations for the two types of bread are as follows:

Brown bread price equation

$$\Delta(\ln PBB_t) = \underset{(1.373)}{-0.0577}\,\Delta(\ln PW_{t-1}) - \underset{(2.067)}{0.0988}\left[\ln PBB_{t-1} - \underset{(6.427)}{2.6278} - \underset{(1.602)}{0.5093}\,D_{02/2008} - \underset{(4.662)}{0.4330}\ln PW_{t-1}\right]$$

White bread price equation

$$\Delta(\ln PWB_t) = \underset{(2.091)}{-0.0943}\,\Delta(\ln PW_t) - \underset{(2.1420)}{0.0666}\left[\ln PWB_{t-1} - \underset{(3.464)}{2.2278} - \underset{(1.851)}{1.4481}\,D_{02/2008} - \underset{(3.6048)}{0.5229}\ln PW_{t-1}\right]$$

Where PBB is the brown bread price, PWB is the white bread price and PW is the price of wheat. The numbers below the coefficients are the t-statistics. The residuals of both equations were tested for normality (Jarque-Bera test), presence of autocorrelation (Breusch-Godfrey Lagrange Multiplier test) and presence of ARCH terms, without any problems being found. In the error correction form, the equation for brown bread explains 34 per cent of the variance (98.3 per cent of the variable in levels) and 43 per cent in the case of white bread (98.6 per cent of the variable in levels).

Three issues are interesting to note from the estimated error correction equations. First, the short term dynamics given by the right hand side terms expressed in first differences; second, the speed of adjustment of the bread prices to disequilibrium, and third, the long term effect given by the equation inside the brackets.

With respect to the short term behaviour, according to the equations, only in the case of white bread is an increase in the price of wheat readily translated into the price of bread, whilst in the case of brown bread it takes one period. The unexpected negative sign in both equations may be associated with a process of adjustment of inventories.

The error correction terms in the equation indicate that the speed of adjustment to movements outside the equilibrium is quite slow. In the case of brown bread prices, only 0.098 per cent of 1 per cent disequilibrium is translated into the bread price in the first period. In the case of white bread prices that response is even lower and equal to 0.067 per cent.

The long term equations that are inside the brackets indicate that the elasticity of the price of brown bread and white bread with respect to changes in the price of wheat are 0.433 and 0.522.

III.2 Demand models

Data

The information used in the paper for the demand analysis, 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 descriptive statistics of the data are presented in Table 1.

Table 1: Scotland - Descriptive statistics of selected supermarket bread data, October 2006 to September 2008 1/2/3/

	Scotland - CAMEO Groups			
	Group A	Group B	Group C	All
Bread quantities (grams per week)				
Brown	932.8	898.8	883.0	906.7
Std. Dev.	25.4	25.6	25.4	23.5
Min	870.4	836.7	837.3	850.8
Max.	1,015.4	988.2	958.0	986.9
Premium brown	712.7	677.2	659.7	688.5
Std. Dev.	29.8	33.5	34.2	29.7
Min	664.3	629.0	617.3	649.6
Max.	801.7	800.0	796.3	789.8
White	1,048.4	1,005.4	1,023.5	1,029.2
Std. Dev.	25.1	21.3	24.5	22.5
Min	983.5	934.7	960.5	964.0
Max.	1,137.9	1,062.7	1,130.5	1,121.8
Premium white	678.4	661.5	649.0	664.5
Std. Dev.	23.1	23.6	21.6	21.3
Min	630.6	625.7	612.4	633.4
Max.	750.1	734.8	714.4	733.1
Bread prices (pence/10 gr.)				
Brown	1.11	1.12	1.11	1.11
Std. Dev.	0.10	0.17	0.10	0.10
Min	0.92	0.90	0.92	0.92
Max.	1.28	1.52	1.29	1.28
Premium brown	1.24	1.25	1.23	1.24
Std. Dev.	0.18	0.17	0.18	0.18
Min	0.92	0.90	0.90	0.91
Max.	1.52	1.52	1.51	1.51
White	1.08	1.10	1.07	1.08
Std. Dev.	0.11	0.12	0.12	0.12
Min	0.91	0.93	0.90	0.91
Max.	1.31	1.33	1.31	1.32
Premium white	1.30	1.30	1.26	1.29
Std. Dev.	0.15	0.15	0.15	0.15
Min	1.08	1.09	1.04	1.07
Max.	1.55	1.53	1.52	1.53

Source: © dunnhumby 2009

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

The data consisted of information on the value of bread purchases in GB pounds, number of units purchased, number of customers and prices per unit in GB pounds; with all variables at the 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 price changes and whether their consumption is somewhat related (i.e., the 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 at the week of the 9th of October 2006 and ending at 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[2]). 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).

As shown in Table 1, the purchases of bread per customer are relatively similar amongst the different groups, although in all cases the most affluent group shows the highest purchase levels per customer.

Estimation

Four demand systems were estimated in the paper: the double log demand system, the Rotterdam demand system and the static and dynamic versions of the so-called Linear Approximation 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 four models was due to the fact that they have been previously used in the literature for demand systems estimation 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

[2] More information about the CAMEO-UK groups can be found at http://www.eurodirect.co.uk/pages/cameo-analysis.

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 on 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 shelf stable fruit juices and drinks.[3] 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):

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

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.

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

[3] 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.

The LA/AIDS model can be found, for instance, in Cotterill (1994) applied to the market of regular carbonated soft drinks[4]. 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):

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

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

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

The dynamic version of the LA/AIDS model can be found, for instance, in Edgerton et al. (1996) applied to food demand in the Nordic Countries. Instead of (5) the share equations are modified by adding the lag of the shares such as in (8):

$$(8) \qquad \omega_{i,t} = \alpha_0 + \sum_{j=1}^{n} \phi_j \omega_{j,t-1} + \sum_{j=1}^{k} \alpha_{ij} \cdot \log(P_{j,t}) + \alpha_{ik+1} \cdot \log\left(\frac{E}{P}\right)_t + \mu_{i,t}$$

It should be noted that to identify the model, additional constraints to those presented in (6) need to be imposed. In this paper, we follow Edgerton et al. (1996) and use $\sum_{j=1}^{n} \phi_j = 0$.

The previously described models were estimated using Iterative Seemingly Unrelated Regressions (SURE). All the estimations were undertaken with the econometric software Shazam version 10.

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

III.3 Demand models 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 Scotland and by socioeconomic group.

All the estimated models produced own-price elasticities for socio-economic groups that were not only statistically significant at 1 per cent, but also with the anticipated 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. Actually they differed and the final results of the effect of the rise of wheat on the bread prices depend on the model chosen.

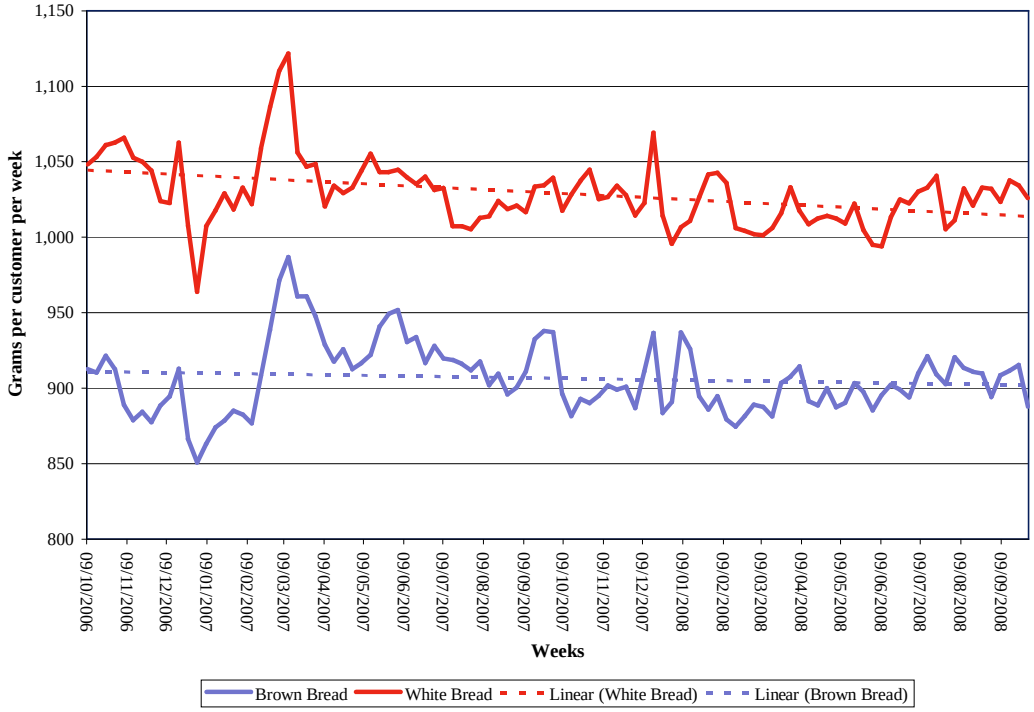
In terms of the results by socioeconomic groups (i.e., results for groups A, B, and C), these were quite similar to those observed for Scotland overall. As regards the results by model, the double log, the Rotterdam models and the dynamic LA/AIDS model all provided relatively close results (except for the premium white bread where the dynamic LA/AIDS gave quite high own price elasticities close to those observed for the static LA/AID). In contrast, the static LA/AIDS model predicted elasticities that were higher than those from the other models.

The results regarding the cross-price elasticities for the different models and socioeconomic groups were interesting and in some ways 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 type of result is not new and can be found in Cotterill (1994) in his study of carbonated soft drinks using scanner data. He 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 (complementary products) were significant. He explained this in the following way: “complementary demand relationships were not expected among these ostensibly competing regular soft drink products [Coke and Sprite]. Intuitively what seems to occur is that when Coke, for example, lowers its price shoppers are attracted to the aisle and pickup some Sprite as a complementary product to provide “variety” or a clear soda for the uncola crowd” (pp. 135). Similarly, it may be that many shoppers purchase premium bread along with ordinary bread, or brown bread with white. 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).[5] Figure 2 shows that the purchases of brown and white bread evolve similarly during the sample period, which is reflected in the cross price elasticities.

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

Figure 2: Scotland - Bread Purchases per Customer - Oct 2006 to Sept 2008



Source: © dunnhumby 2009

What are the implications of the results in nutritional terms? In other words, what is it possible to say in relation to 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 considered.

Table 3 presents the results of the overall change in the bread purchases due to the change in the price of wheat. The table evaluates the effect of an increase in the price of brown bread by 31.2 per cent and in white bread by 37.7 per cent. These percentages were the results of multiplying the long term elasticity of bread prices with respect to wheat prices (0.43 and 0.52 for brown bread and white bread, respectively) by 72.4 per cent, i.e., the change in the milling wheat price in Great Britain during the period January 2005 to September 2008. The prices for brown bread and white bread were also applied to the premium categories.

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

	Double log demand system										Rotterdam demand system									
	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.
Group A																				
Brown	-0.739	*	-0.127	*	0.132		-0.112	*	0.809	*	-0.572	*	-0.174	*	-0.106		-0.125	*	0.977	*
Premium Brown	0.085		-0.446	*	-0.319	*	-0.128	*	0.829	*	-0.231	*	-0.487	*	-0.236	*	-0.127	*	1.081	*
White	-0.264	*	-0.121	*	-0.339	*	-0.139	*	0.824	*	-0.098		-0.161	*	-0.544	*	-0.180	*	0.983	*
Premium White	0.115		-0.065	*	-0.410		-0.442	*	0.805	*	-0.144	*	-0.101	*	-0.228	*	-0.493	*	0.967	*
Group B																				
Brown	-0.682	*	-0.101	*	0.041		-0.109	*	0.795	*	-0.727	*	-0.148	*	-0.074		-0.098		1.046	*
Premium Brown	0.054		-0.473	*	-0.214		-0.157	*	0.905	*	-0.212	*	-0.523	*	-0.257	*	-0.185	*	1.178	*
White	-0.178	*	-0.133	*	-0.387	*	-0.161	*	0.831	*	-0.018		-0.126	*	-0.541	*	-0.176	*	0.861	*
Premium White	0.080		-0.070	*	-0.410	*	-0.406	*	0.789	*	-0.090		-0.132	*	-0.253	*	-0.476	*	0.951	*
Group C																				
Brown	-0.807	*	-0.111	*	0.148		-0.089	*	0.735	*	-0.523	*	-0.122	*	-0.186	*	-0.118	*	0.950	*
Premium Brown	0.220	*	-0.483	*	-0.327	*	-0.195	*	0.931	*	-0.187	*	-0.521	*	-0.200	*	-0.188	*	1.096	*
White	-0.261	*	-0.123	*	-0.352	*	-0.128	*	0.831	*	-0.194	*	-0.138	*	-0.596	*	-0.128	*	1.056	*
Premium White	0.144		-0.080	*	-0.430	*	-0.438	*	0.796	*	-0.126	*	-0.140	*	-0.123	*	-0.501	*	0.890	*
Altogether																				
Brown	-0.738	*	-0.115	*	0.114		-0.112	*	0.780	*	-0.539	*	-0.164	*	-0.170	*	-0.136	*	1.009	*
Premium Brown	0.155		-0.458	*	-0.334	*	-0.158	*	0.883	*	-0.182	*	-0.469	*	-0.184	*	-0.125	*	0.959	*
White	-0.275	*	-0.128	*	-0.310	*	-0.149	*	0.825	*	-0.171	*	-0.165	*	-0.559	*	-0.178	*	1.073	*
Premium White	0.118		-0.074	*	-0.433	*	-0.414	*	0.797	*	-0.141	*	-0.119	*	-0.193	*	-0.483	*	0.935	*

Continues

Source: Own elaboration based on dunnhumby data, © dunnhumby 2009.

Notes:

1/ "*" stands for statistically significant at 1 per cent.

2/ Elasticities read from left to right in the table

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

	LA/AIDS Static										LA/AIDS Dynamic (short term elasticities)									
	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.
Group A																				
Brown	-1.025	*	-0.444	*	-0.491	*	0.470		1.491	*	-0.776	*	-0.174	*	-0.066		-0.143	*	1.159	*
Premium Brown	-0.463	*	-0.739	*	-0.520	*	0.452		1.270	*	-0.138	*	-0.544	*	-0.159	*	0.063		0.904	*
White	-0.356		-0.374	*	-0.930	*	0.515		1.146		0.007		-0.123	*	-0.669	*	-0.121	*	0.905	*
Premium White	-0.222		-0.256		-0.285		-3.668	*	1.789	*	-1.308	*	-1.093	*	-1.485	*	-1.613	*	1.931	*
Group B																				
Brown	-0.980	*	-0.383	*	-0.518	*	0.425		1.456	*	-0.769	*	-0.125	*	-0.089		-0.121	*	1.104	*
Premium Brown	-0.364		-0.699	*	-0.491	*	0.611		1.095		-0.110		-0.594	*	-0.056		-0.107		0.953	*
White	-0.372		-0.347	*	-0.804	*	0.447		1.076		-0.001		-0.099	*	-0.542	*	-0.159	*	0.801	*
Premium White	-0.364		-0.378		-0.480		-3.500	*	1.884	*	-1.340	*	-1.105	*	-1.606	*	-1.579	*	1.762	*
Group C																				
Brown	-1.001	*	-0.375		-0.647		0.295		1.728	*	-0.781	*	-0.107	*	-0.158	*	-0.160	*	1.206	*
Premium Brown	-0.230		-0.652	*	-0.486		0.582		1.407	*	-0.014		-0.625	*	-0.049	*	-0.088		0.767	*
White	-0.491	*	-0.347	*	-0.905	*	0.335		0.874		-0.096		-0.113	*	-0.676	*	-0.153		1.038	*
Premium White	-0.308		-0.413		-0.388		-3.098	*	2.479	*	-1.315	*	-1.074	*	-1.517	*	-1.556	*	2.226	*
Altogether																				
Brown	-1.010	*	-0.427	*	-0.587	*	0.408		1.616	*	-0.779	*	-0.147	*	-0.117	*	-0.159	*	1.202	*
Premium Brown	-0.357		-0.689	*	-0.498	*	0.637	*	1.048	*	-0.059		-0.568	*	-0.001		-0.083		0.766	*
White	-0.426	*	-0.373	*	-0.876	*	0.458		1.217	*	-0.038		-0.115	*	-0.639	*	-0.153	*	0.945	*
Premium White	-0.257		-0.312		-0.336		-3.516	*	2.073	*	-1.332	*	-1.101	*	-1.540	*	-1.572	*	2.108	*

Source: Own elaboration based on dunnhumby data, © dunnhumby 2009.

Notes:

1/ "*" stands for statistically significant at 1 per cent.

2/ Elasticities read from left to right in the table

Table 3: Scotland - Simulation of the total effect of an increase in the price of wheat on the purchases of the different types of bread , 2005-08 (%)

	Double log demand system	Rotterdam demand system	LA/AIDS Static	LA/AIDS Dynamic
Group A				
Brown	-31.22	-27.96	-64.29	-35.01
Premium Brown	-30.71	-36.04	-57.04	-27.22
White	-29.98	-32.31	-46.72	-33.56
Premium White	-18.70	-34.84	..	..
Group B				
Brown	-28.48	-27.24	-61.98	-32.42
Premium Brown	-20.67	-39.57	-40.27	-18.51
White	-30.34	-30.92	-41.12	-29.51
Premium White	-32.94	-31.57	..	..
Group C				
Brown	-31.97	-31.59	-31.20	-39.65
Premium Brown	-27.83	-36.68	-20.31	-21.29
White	-30.03	-37.62	-60.19	-28.99
Premium White	-35.15	-31.79	..	..
Altogether				
Brown	-30.81	-33.41	-66.91	-39.26
Premium Brown	-32.82	-31.90	-16.23	-17.69
White	-29.88	-38.23	-57.89	-33.41
Premium White	-34.22	-33.55	..	..

Source: Own elaboration based on dunnhumby data, © dunnhumby 2009.

With the exception of the results of the static LA/AIDS model, the results of the remaining models seem to be similar in magnitude, most of then fluctuating around 30 per cent and all indicating a decrease in the purchases of bread. However, if one would like to answer the question whether the changes in bread purchases will be the same for all the socioeconomic groups and what type of bread will suffer the highest decrease, the different model provide different results.

As regards the question of whether all the socioeconomic groups will have the same response to the increase in prices, the models provide different responses. According to the Rotterdam model and the dynamic LA/AIDS all the socioeconomic groups will have a similar response; however the models predict in opposite directions, whilst the remaining two models predict mixed responses by group.

Regarding the purchase of what type of bread was more strongly affected by the rise in the price of wheat, the findings are also mixed. According to the Rotterdam model, white bread in comparison with brown bread is the one with the highest decrease whilst according to the dynamic LA/AIDS the answer is just the opposite. In

other words, according to the former the increase in wheat prices would have had a positive impact on Scottish nutritional intake in all the socioeconomic groups, whilst according to the latter the impact would have been negative. According to the double log model, except in the case of the group B, the impact on nutrition would have been negative. The static LA/AIDS also predicts a negative outcome except in the case of the group C (poorer).

If one focuses on the results altogether, excluding the static LA/AIDS model, the models predict a decrease in the purchases on brown bread that ranges from 30.81 per cent to 39.26 per cent and a decrease on the purchase of white bread that goes from 29.88 per cent to 38.23 per cent.

IV. Conclusions

The overall purpose of the paper has been to measure the impact that the increase in the price of cereals has had during the period 2005 to 2008 on the purchase of brown and white bread. This has been achieved by first measuring the effect of changes in wheat milling prices on brown and white bread prices, and second by measuring the demand elasticities for brown and white bread with respect to changes in their prices through the estimation of four demand systems.

Overall, with the exception of the results of the static LA/AIDS model, the results of the remaining models seem to be similar in magnitude, most of them fluctuating around 30 per cent and all indicating a decrease in the purchases of bread. When one considers all the socioeconomic groups (i.e., Scotland) and excludes the results of the static LA/AIDS model, the models predict a decrease in the purchases on brown bread that ranges from 30.81 per cent to 39.26 per cent and a decrease in the purchase of white bread that goes from 29.88 per cent to 38.23 per cent. However, as regards what type of bread decreases more the different demand models provide opposite responses. In general, the implications of these findings include the proposition that during periods of high wheat price escalation, the health messages associated with whole grain and brown bread consumption need to be maintained.

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