Estimating Price Premiums for Breads Marketed as "Low-Carbohydrate Breads"

William Nganje, Simeon Kaitibie, Cheryl Wachenhiem, Emmanuel T. Acquah, Joel Matson and Grant Johnson

Retail data are used in a hedonic pricing framework to estimate the premium paid for the "low-carbohydrate" attribute and other attributes of bread at grocery and non-grocery stores in a regional market. Results show that consumer willingness to pay is influenced by the "low-carbohydrate" attribute as well as by sugar, fiber, and fat content; serving size; and size of loaf. Implicit price premiums vary significantly by retail location. However, price differentials may be compounded by the absence of an acceptable definition for low-carbohydrate foods.

Mr. Scott[1] is the manager of a major food retail company that is considering marketing low-carbohydrate bread. He has an MS degree in Agribusiness and has been manager of this company, which has several stores in the Minnesota and North Dakota area, for about 12 years. In the last five years he has noticed an increase in sales of low-carbohydrate bread.[2] Packaged Facts (2006) noted that bread sales in the United States increased by 1.1 percent in 2005, from $13.6 billion in 2004 to $13.7 billion. A significant portion of the increase is a result of new bread products emphasizing healthier whole grains and increased fiber.

A food retailer such as Mr. Scott could take advantage of the increased demand for low-carbohydrate products by marketing low-carbohydrate bread, but he faces a number of questions. He needs to know how much of a premium can be received by labeling the bread as low-carbohydrate, what constitutes low-carbohydrate bread, the value of other characteristics of the bread, and what characteristics are needed to obtain the highest premium. If the low-carbohydrate attribute is correlated with other attributes, such as being low in calories, then the manager needs to know the marginal contributions of each attribute to the premium. Knowing the premiums that could be achieved provides some information about the profit potential of marketing low-carbohydrate bread.

Mr. Scott would like to explore the use of a hedonic pricing framework to estimate the premium

[1] Names have been changed to preserve the identity of this retailer.

[2] Low-carbohydrate diets are different from low-carbohydrate breads. Packaged Facts (2006) noted in 2005 that as consumers bid farewell to low-carb diets new bread products flooded the market emphasizing healthier whole grains. Low-carb breads can be made by increasing the amount of fiber or producing smaller slices or loaf sizes. In Europe, and Germany in particular, low-carb breads are viewed as functional breads (with health attributes from higher fiber content) and their sales are expected to increase by about 15 percent in 2008 (Benkouider, 2004).

Nganje is associate professor, Morrison School of Management and Agribusiness, Arizona State University, Mesa. Kaitibie is senior economist, ILRI. Wachenheim is associate professor, Matson is Ph.D. candidate, and Johnson is former research assistant, Department of Agribusiness and Applied Economics, North Dakota State University, Fargo. Acquah is associate professor and acting VP, University of Maryland Eastern Shore.

We thank David Forsyth and three anonymous reviewers for their comments.

that consumers are willing to pay for the low-carbohydrate attribute and other attributes in bread in the Upper Midwest region of Minnesota and North Dakota, the largest market for Mr. Scott's company. He understands that the hedonic pricing framework would be an appropriate method for such analysis if the parameter estimates are robust and unbiased. Other methods available to estimate price premiums and consumer willingness to pay for alternative product attributes include choice experiments and experimental auctions, but these are more appropriate for non-market goods and are more costly and time consuming. The hedonic pricing framework is based on the concept that the quality of a good is related to some measurable specification variables (Deaton and Muellbauer 1980).

He has identified from previous studies that product attributes and store characteristics affect prices. However, management wishes to understand how these attributes apply to low-carbohydrate bread. Other objectives he wishes to investigate are to compare the markets for low-carbohydrate breads, determine the marginal impacts of major factors affecting price premiums associated with low-carbohydrate breads, estimate price premiums for the low-carbohydrate attribute in bread, and derive implications for short- and long-run demand trends.

Background on Low-Carbohydrate Foods

A substantial portion of U.S. food expenditures has been on products containing concentrated sugars and refined starches. The resulting high-carbohydrate intake is a major cause of obesity and is the second-leading preventable cause of death in the United States (Mokdad et al. 2004). Today, nearly two out of three adult Americans fall under the categories of overweight or obese (Philipson et al. 2004). Obesity accounts for about $117 billion a year in direct and indirect economic costs, and its associated effects cause approximately 300,000 deaths each year (Mancino, Lin, and Ballenger 2004).

There have been a number of high-profile public and private efforts to address this growing problem. Some initiatives include changes in the USDA food pyramid and increased adoption of low-carbohydrate diets. The food pyramid has been revised with an objective of making consumers more aware of and able to recognize the difference between types of carbohydrates so that they chose, for example, more unprocessed cereal grains and whole wheat bread instead of white bread to increase the fiber content of their diet (Dietary Guidelines Advisory Committee 2004). The increase in sales of low-carbohydrate breads observed by Mr. Scott is due to growing consumer awareness about the health problems from diets high in carbohydrates and about the increased fiber content of whole grain bread.

Interest in low-carbohydrate foods is showing up in many product categories tracked by ACNielsen (2004). Data from ACNielsen (2004) suggest that at its height of popularity, more than 17 percent of U.S. households had someone who was on a low-carbohydrate diet. The low-carbohydrate food class grew from $10 million in 1997 to more than $1.4 billion in 2003 (Nutrition Business Journal 2004). Forty percent of adults in the United States—an estimated 83.6 million people—reported that they reduced their carbohydrate intake (Mintel International Group Limited 2004), and an estimated six to seven percent of consumers were on a low-carbohydrate diet in 2004. Although the trend began to wane after 2004, there is still strong demand for healthy food products such as low-carbohydrate and whole grain bread. Goldberg and Bucciarelli (2006) argued that despite the drop in public interest for the low-carbohydrate diet, the diet still maintains some popularity, and they document how low-carbohydrate diets have cycled in and out of fashion for more than a century. They predict that the low-carbohydrate diet is likely to rebound in a matter of time. It should however be noted that sales of low-carbohydrate breads with high fiber content remain strong.

There are no existing regulations permitting the use of carbohydrate claims on foods, as there is no legal definition of a "low (or reduced) carbohydrate diet." However, in a study that used USDA's Continuing Survey of Food Intakes by Individuals, Bowman and Spence (2002) used the term "low-carbohydrate diets" to describe foods that provided no more than 45 percent of energy intake from carbohydrates. A low-carbohydrate diet is naturally one that limits the intake of carbohydrates (Allan and Lutz 2000). Proteins and fats from plants and animals compose a larger percentage of the diet.

Although there is no official definition of the low-carbohydrate claim, firms are taking advantage

of increased public awareness by developing new low-carbohydrate products to entice consumers. Consumers are also becoming aware of the effect of diet on their health and as a result, they are changing purchasing habits. The last decade has brought the potential weight-reduction benefits of low-carbohydrate diets to public attention. The bread market is particularly affected by a decrease in consumption of carbohydrates, and, therefore, development and marketing of a low-carbohydrate product has particular appeal for this industry. There is reason to believe that consumers value low-carbohydrate alternatives to traditionally consumed products, although little work exists which quantifies this value.

Economic theory suggests that some consumers will pay a premium for goods providing them additional utility (e.g., high fiber content in low-carbohydrate breads). The demand for goods and services used for maintenance or improvement of one's health tend to increase as income increases (Grossman 1972). According to the concept of full income (Becker 1965), higher wages, such as those evident in the United States, and the resultant inflated value of time may induce consumers to purchase goods and services that are more convenient, better prepared, or perceived to be of a higher quality. Knowing the amount that consumers are willing to pay for low-carbohydrate bread will help Mr. Scott price his products at a level that will maximize his revenue.

Methods

Mr. Scott understands that a variety of methods are available to value non-marketed attributes and estimate price premiums and consumer willingness to pay for alternative product attributes. Among them are choice experiments (Alpizar, Carlsson, and Martinsson 2001), experimental auctions (Lusk, Feldkamp, and Schroeder 2004), surveys, and hedonic pricing (Rosen 1974). He understands that choice experiments and experimental auctions are more appropriate for non-market goods. He is also constrained by time and budget to conduct meaningful choice experiments and experimental auctions. However, he can use data collected from retail stores to develop a hedonic pricing model and analyze the price premium paid for low-carbohydrate bread. The basic premise of the hedonic pricing method is that the price of a marketed good is related to its quality and quantity characteristics. Maguire, Owens, and Simon (2004) used a hedonic pricing model to estimate price premiums for organic baby foods in regional markets. An advantage of hedonic pricing methods is the ability to use over-the-counter data on quantity, prices, and other store characteristics to estimate premiums for product quality characteristics.

Model

The hedonic pricing framework is used to estimate price for the low-carbohydrate characteristic of bread. Several studies have used the hedonic pricing approach to derive implicit prices for food quality and nutritive attributes (Brooker, Terry, and Eastwood 1986; Stiegert and Blanc 1997; Salayo, Voon, and Selvanathan 1999). Following Rosen (1974), the statistical framework is a multiple regression model which assumes that consumers purchase one unit of a differentiated good such as a loaf of bread consisting of n component characteristics including

[3] Let us assume that consumers purchase one unit of a differentiated good, y, such as a loaf of bread. Bread consists of n component characteristics, such as y_1 for low carbohydrate, y_2 for serving size, through y_n. If u is consumer utility and x is a composite good, consumers will maximize $u(x, y)$ subject to a budget constraint, $m = x + p(y)$, where m is income and $p(y)$ is the price of bread. The price of the composite good is normalized to one, and the market is assumed to be competitive so consumers take prices as given. The maximization problem yields first-order conditions

$$\text{(a)} \quad \frac{\partial u / \partial yi}{\partial u / \partial x} = \frac{\partial p}{\partial yi}, \forall i = 1, ..., n.$$

[4] On the supply side of the market, producers are maximizing their profits, π, by choosing an amount (T) to produce the good y, which consists of component characteristic, $y_1,\ldots,y_n$. Total revenues are equal to $Tp(y)$. Again, markets are assumed to be competitive and firms take prices as given. Costs of production are $c(T, y; \beta)$, where β is a parameter describing variables in the cost-minimization problem, such as factor prices. Therefore, the profit function is $\pi = Tp(y) - c(T, y; \beta)$. Firms maximize profits by choosing the amount of y to produce, such that the following conditions hold:

$$\text{(b)} \quad \frac{\partial p}{\partial yi} = \frac{\partial C / \partial yi}{T}, \forall i = 1, ..., n$$

low-carbohydrate, other nutritional characteristics, and store type and shelf allocation.

The market for bread is assumed to be competitive so that, for price-taking consumers, utility is maximized when the marginal rate of substitution between the low-carbohydrate characteristic and the composite good, bread, equals the marginal price of the characteristic. A quality attribute such as "low-carbohydrate" will be consumed up to the point where the consumer's marginal willingness to pay for the attribute equals its marginal price.[3] On the supply side, markets are also assumed to be competitive so that firms are price-takers in maximizing profit. The profit-maximizing level of production occurs where the per-unit marginal cost of producing the low-carbohydrate characteristic is equal to the marginal price of that characteristic.[4] The aforementioned assumptions suggest that under optimal market conditions, the relative value consumers place on the component characteristic is equivalent to the per-unit marginal cost of producing the characteristic.[5] This enables us to analyze price premiums of low-carbohydrate bread based on posted or observed prices rather than on actual market transactions. Rosen (1974); Samikwa, Brorsen, and Sanders (1998); and Maguire, Owens, and Simon (2004) explain how data on posted prices and characteristics can be used to estimate the marginal value of one characteristic, holding all others constant.

Using the hedonic pricing framework, over-the-counter data on prices, quantity, and other store characteristics can be used to estimate values based on actual choices.[6] The main objective of this case study is to estimate regional price premiums for the low-carbohydrate characteristic in bread. However, there are other very important food quality characteristics, which are identified based on earlier works by Maguire, Owens, and Simon (2004); Nayga (1998); and Kantor (1998).

Bread price is established in cents per gram of product, and a low-carbohydrate dummy variable is included to identify all breads sold as low-carbohydrate to as 1 and others as 0. The product characteristics include serving size, product quantity per package, and quality and nutritional attributes such as total calories, total fat, protein content, carbohydrate content, sugar content, and fiber content, all expressed in grams per serving. The study evaluates the importance of these other quality attributes or nutritional characteristics and estimates their price premiums. This is necessary because low-carbohydrate claims are generally made in concert with other nutritional claims that contribute to high product quality. While the low-carbohydrate claim is very important, consumer demand for more nutritious foods follows a holistic view of associated attributes. Data on store characteristics used for the analysis include store type, store location, and amount of shelf space allocated to bread. Accordingly, data for this study were collected from grocery and non-grocery stores for multiple varieties of low-carbohydrate and conventional bread in the twin-city metro area of Fargo, North Dakota and Moorhead, Minnesota.

In the hedonic pricing framework, theory does not provide a basis for selecting any particular functional form. However, linear models have been used because the parameters are directly interpretable as implicit prices, and thus easier to explain (Samikwa, Brorsen, and Sanders 1998). Accordingly, a linear model is specified as

$$(1)\quad P_i = \alpha_0 + \alpha_1 LC_i + \alpha_2 SS_i + \alpha_3 PS_i + \alpha_4 CAL_i + \alpha_5 PRO_i + \alpha_6 CAR_i + \alpha_7 S_i + \alpha_8 FIB_i + \alpha_9 FAT_i + \alpha_{10} SH_i + \varepsilon_i,$$

where P_i is the price of the ith bread product in cents per gram; LC_i is a dummy variable equal to 1 if the ith product is low-carbohydrate and 0 otherwise; SS_i is the serving size of the ith product in grams per serving; PS_i is package size for the ith product measured in number of slices per package; CAL_i is calories per serving for the ith product; PRO_i, CAR_i, S_i, FIB_i, and FAT_i are grams per serving of protein,

[5] From Equations (a) and (b) (see notes 3 and 4), the following relationship holds:

$$(c)\quad \frac{\partial p}{\partial yi} = \frac{\partial u / \partial yi}{\partial u / \partial x} = \frac{\partial C / \partial yi}{T}.$$

The price of a component characteristic, y_i, represents both the relative value consumers place on the characteristic and the per-unit marginal cost of producing the characteristic. Therefore, the price of y_i represents optimal behavior by both sides of the market.

[6] Discussions with other store managers in the region revealed that more than 95 percent of the low-carbohydrate breads are purchased at posted prices. The assumption of market-clearing price seems reasonable under these conditions.

carbohydrates, sugar, fiber, and fat, respectively, for the *i*th product; SH_i is shelf space, measured in feet, for the *i*th product; and ε_i is the error term which is assumed to be normally distributed.

Data Collection Procedure and Descriptive Statistics of Data

Data were collected in July, 2004 from all grocery and non-grocery stores that sell low-carbohydrate breads across Fargo, North Dakota and Moorhead, Minnesota. These stores are listed in the Fargo-Moorhead Yellow Book. The data collection was carried out when sales promotions for bread were not indicated within the venues. The product labels identified the breads as low-carbohydrate or conventional breads. Other product characteristics such as serving size, package size, calories, protein, fat, and fiber content were also printed on the labels. The study uses observations from grocery and discount stores that sold one or more low-carbohydrate bread product. Table 1 shows the breakdown of observations by store type and location.

There are 681 observations: 466 observations from Fargo stores and 215 from Moorhead stores. Among these are 394 observations from Fargo grocery stores, 72 observations from other stores in Fargo, 172 observations from Moorhead grocery stores, and 43 observations from other stores in Moorhead. Means and standard deviations of price, product characteristics, and shelf space allocation data are provided by store type and location in Table 2. As suggested by hedonic pricing theory, product price is measured as a continuous variable. Approximately 101 of the 681 observations are low-carbohydrate breads. Among the 101 low-carbohydrate observations, there are 20 observations from non-grocery stores and 81 observations from grocery stores.

For the composite dataset, the average serving size is about 31.8 grams, and the difference among store locations or store types is marginal. Average serving size for low-carbohydrate breads is lower, 25.0 grams, compared to 33.4 grams for conventional breads. Package size is marginally higher for conventional breads, 19.8 slices compared to 18.8 slices for low-carbohydrate breads. The calories per serving of low-carbohydrate bread is 52.2, while that of conventional bread is significantly higher, 86.8. Average protein content for all breads is 3.4 grams per serving, ranging from 3.2 grams for conventional breads to nearly 4 grams for low-carbohydrate breads.

There is no legal definition for the low-carbohydrate attribute; therefore, this study also evaluates the amount of carbohydrates per serving for all breads. The total amount of carbohydrates averages about 15.1 grams per serving, with a range of about 8.8 grams for low-carbohydrate breads to nearly 16.7 grams for conventional breads. This difference is statistically significant; therefore, the low-carbohydrate characterization is a reasonable one. The sugar content averages 2.2 grams per serving for all breads. Low-carbohydrate breads have an average sugar content of 0.7 grams, whereas the conventional breads have an average sugar content of 2.6 grams. Other quality attributes such as fiber and total fat are also evaluated. Average fiber content per serving is estimated at 2.7 grams and 1.7 grams for low-carbohydrate and conventional

Table 1. Sources and Number of Observations for Survey Data.

	Distribution by Location			
	Moorhead		Fargo	
Store type	No. of stores	No. of observations	No. of stores	No. of observations
Grocery store	4	172	10	394
Other stores	4	43	6	72
Total	8	215	16	466

Note: "Other stores" include discount stores and convenience stores.
Data were collected in July of 2004.

Table 2. Means and Standard Deviations for Survey Data.

Variable	Description	Moorhead		Fargo	
		Grocery	Non-grocery	Grocery	Non-grocery
		Price			
Price	Cents/gram	0.435	0.357	0.454	0.389
		(0.191)	(0.094)	(0.194)	(0.119)
Price (conventional bread)	Cents/gram	0.404	0.344	0.413	0.372
		(0.141)	(0.091)	(0.129)	(0.122)
Price (low carbohydrate)	Cents/gram	0.637	0.440	0.688	0.458
		(0.319)	(0.077)	(0.310)	(0.083)
		Product characteristics			
Serving size	Grams per serving	32.224	32.767	32.134	28.625
		(6.681)	(7.160)	(6.827)	(8.059)
Package size	Slices per package	19.198	20.279	19.094	25.764
		(4.177)	(3.142)	(4.327)	(11.269)
Calories	Amount per serving	80.756	86.977	79.543	85.000
		(19.271)	(21.716)	(19.768)	(23.957)
Protein	Grams per serving	3.247	3.372	3.211	3.403
		(0.996)	(1.064)	(0.956)	(1.009)
Carbohydrates	Grams per serving	15.478	16.767	15.261	16.500
		(3.749)	(3.999)	(3.771)	(4.783)
Sugar	Grams per serving	2.229	2.395	2.272	2.639
		(1.111)	(1.067)	(1.836)	(1.859)
Fiber	Grams per serving	1.791	1.814	1.766	1.972
		(0.957)	(1.052)	(0.981)	(1.074)
Total fat	Grams per serving	1.026	1.139	0.999	1.028
		(0.409)	(0.467)	(0.418)	(0.697)
		Store characteristics			
Shelf space	Feet	3.086	3.032	3.102	3.164
		(4.948)	(3.179)	(3.811)	(2.971)
Observations		172	43	394	72

breads, respectively. In addition, average total fat content is estimated at 0.7 grams and 1.1 grams per serving for low-carbohydrate and conventional breads, respectively. The descriptive statistics show that the low-carbohydrate designation is appropriate, and that other quality attributes are incorporated into these low-carbohydrate breads to make them high-quality products.

Model Estimation

The choice of functional form in the hedonic pricing framework is not underscored by theory. Caution should be used to prevent identification problems. Ekeland, Heckman, and Nesheim (2001) noted that much of the confusion in the empirical literature about whether hedonic models estimated on data from a single market are fundamentally under-identified is based on linearizations that do not use all of the information in the model. Maguire, Owens, and Simon (2004), noted that information attributes can vary independently of each other, so the linear hedonic price function is appropriate. It should also be noted that identification problems are avoided in this study by including the attributes of interest (carbohydrate, fiber, and serving size) for low-carbohydrate breads. The estimation process follows diagnostic tests for aggregation across store types and for normality, homoskedasticity, and multicollinearity.

The locations where the data were collected (i.e., Fargo and Moorhead) are not considered separately because it is assumed that costs of movement between Fargo and Moorhead are negligible. On the other hand, the venue in which bread was sold (i.e., grocery and non-grocery stores) are considered separately because they may represent different costs to consumers. Heterogeneity within the composite dataset might lead to inaccurate parameter estimates; therefore, an F-test is performed to determine whether separate models are required or if the data should be aggregated. If homogeneity is confirmed, a single model would be identified and estimated for the complete dataset. The null hypothesis of homogeneity is rejected (F-value = 317.67; p = 0.0001), indicating that the overall dataset is heterogeneous, and this heterogeneity is also defined by store type. Hence the results are therefore reported by store type.

The types of variables employed in Equation 1 raise concerns about multicollinearity, a problem which usually leads to large variance estimates, which in turn leads to statistical insignificance. A formal test for multicollinearity is performed using variance inflation factors (Chatterjee and Price 1991). The variance inflation factor is defined as

$$(2)\quad VIF = \frac{1}{1 - R_i^2}\ ,$$

where R^2 is the multiple correlation coefficient when the ith predictor is taken as the outcome that is predicted by the remaining variables. As a rule, variance inflation factors of ten and above symbolize problems of multicollinearity in the model. In this exercise, VIF measures of ten or higher are observed for the carbohydrates and total-calories variables in grocery and non-grocery data. To solve the problem, the carbohydrates variable is dropped from further consideration in all models. This will not affect model capabilities with respect to the objectives of this study.

One important assumption of the classical linear regression model is that the variances of the disturbances or error terms are constant (homoskedastic). If homoskedasticity is rejected, the ordinary least squares (OLS) estimator is no longer efficient. White's test is used to test for heteroskedasticity. An advantage of White's test is that it makes no assumptions about the form of the heteroskedasticity. White's test statistic is asymptotically distributed as a χ^2 with degrees of freedom equal to the number of slope coefficients. Heteroskedasticity is confirmed in the datasets for grocery stores (χ^2 = 161.0; p = 0.0001) and non-grocery stores (χ^2 = 101.9; p = 0.0001).

As an assumption of the classical linear regression model, normality is also tested. Results from the Kolmogorov-Smirnov test reject the assumption of error term normality in the grocery stores dataset (K-S statistic = 0.113; p = 0.01) and the non-grocery stores dataset (K-S statistic = 0.096; p = 0.01). Under these circumstances (heteroskedasticity and

[7] Consistency can be conceptualized as the large-sample equivalent of the minimum mean square error property, since a consistent estimator has, in the limit, zero bias and zero variance (Kennedy 1992). Like consistency, asymptotic normality is a large-sample property.

Table 3. MLE Parameter Estimates by Store Type.

Variables	Grocery stores	Non-grocery stores
Intercept	1.8850**	0.2098*
	(0.0441)	(0.1058)
Low carbohydrate	0.0788**	0.1612**
	(0.0145)	(0.0364)
Serving size	-0.0191**	-0.0012
	(0.0009)	(0.0022)
Package size	-0.0422**	0.0005
	(0.0012)	(0.0020)
Calories	0.0001	0.0003
	(0.0004)	(0.0008)
Protein	-0.0098	0.0050
	(0.0068)	(0.0140)
Sugar	0.0096**	0.0269**
	(0.0026)	(0.0093)
Fiber	0.0092	0.0196
	(0.0058)	(0.0113)
Total fat	-0.0227*	0.0263
	(0.0116)	(0.0167)
Shelf space	-0.0061**	-0.0048
	(0.0009)	(0.0031)
Observations	566	115
-2 Res Log likelihood	-1075.7	-160.8

** and * imply statistical significance at one percent and five percent, respectively.
Numbers in parentheses are standard errors.

non-normality), the OLS estimator would no longer be unbiased, and therefore it is inappropriate. By correctly adjusting the likelihood function following the normal distribution results, the MLE will provide consistent and asymptotically normal parameter estimates.[7]

Model Results

Table 3 shows MLE parameter estimates by store type. The low-carbohydrate variable is statistically significant at one percent for both estimated models, indicating its importance as a quality attribute to bread pricing and consumer demand. The positive sign indicates a price premium for the low-carbohydrate quality attribute in breads, which is consistent with expectations. Serving size and quantity per serving are highly significant variables in the grocery store model, and they have a negative effect on pricing, indicating consumers will pay more per unit volume for smaller serving size and quantity. This follows descriptive statistics results which

show that low-carbohydrate breads usually have lower serving sizes and quantities per serving than do conventional breads.

The amount of calories per serving is insignificant in all models, indicating that consumer willingness to pay is not affected by the amount of calories. Protein is also not statistically significant in any of the store models, indicating that consumers do not select bread type based on protein content.

Sugar content is significant and positive for grocery stores and non-grocery stores. This suggests that while consumers will pay more for low-carbohydrate bread, pricing is still being positively influenced by sugar content. These results may seem contradictory, but it could be explained by there being some consumers who are willing to pay a premium for low-carbohydrate bread and others willing to pay a premium for sweeter bread. Children and families, for example, may have a preference for sweeter breads. High fiber content may be seen as an important quality attribute in breads marketed as low-carbohydrate breads. This variable is positive, which would indicate that consumers are willing to pay a premium for higher fiber content, but it is only marginally significant at the ten-percent level.

In the grocery store model, total fat is negative and statistically significant, as expected, indicating that consumers will pay more for lower fat content. The amount of space allocated to the bread product is also negative and significant. Each product is given a certain amount of shelf space; for example, discount brands sell at lower prices and have more shelf space, whereas name-brand breads have less shelf space with fewer loaves at a higher price.

The lack of statistical significance among variables in the non-grocery model may be due to data defects such as a relatively small sample size, which leads to a lack of variability. For the purpose of this study, the effectiveness of the grocery store model in evaluating the impact of certain quality attributes is sufficient to capture associated price premiums.

Implicit Prices of Quality Attributes in Low-Carbohydrate Bread

Results show significant and positive parameter estimates for the low-carbohydrate variable across store types. Based on hedonic pricing theory, the results suggest that consumers are willing to pay a premium for low-carbohydrate bread over the conventional type. The implicit price of the product attribute can be obtained by calculating the marginal effects of each attribute. For example, from Table 4, it is shown that consumers are willing to pay a premium for low-carbohydrate bread of about 0.08 cents per gram in grocery stores and 0.16 cents per gram in non-grocery stores above the price of conventional bread. For a 600-gram loaf of bread, this converts into a price premium of $0.47 per loaf in grocery stores and $0.97 per loaf in non-grocery stores. The price premium is consistent with higher prices for low-carbohydrate bread at grocery stores. Results also show that consumers are willing to pay a premium for sugar content. The implicit price of

Table 4. Implicit Price of the Low-Carbohydrate and Other Quality Attributes.

Quality attribute	Implicit price	
	Grocery stores (cents/gram)	Non-grocery stores (cents/gram)
Low carbohydrate	0.0788 ($0.47/loaf)*	0.1612 ($0.97/loaf)*
Serving size	-0.0191	
Package size	-0.0422	
Sugar	0.0096	0.0269
Total fat	-0.0227	
Shelf space	-0.0061	

*Assumes a loaf of bread weighs 600 grams (obtained from observed data).

one gram of sugar per serving is calculated at $0.06 per loaf in grocery stores and $0.16 per loaf in non-grocery stores. The price premium for sugar may exist because children and other consumers may prefer sweeter bread.

Attributes with negative signs are those for which consumers are willing to pay a premium for smaller amounts. Consumers will pay 0.023 cents per gram ($0.14 per loaf) more for a decrease in fat content of one gram per serving in grocery stores. Consumers will also pay 0.019 cents per gram ($0.11 per loaf) more for a decrease in serving size of one gram and they will pay 0.042 cents per gram more for a decrease of one slice per package in grocery stores.

Summary and Conclusions

Low-carbohydrate diets are different from low-carbohydrate breads. Packaged Facts (2006) noted in 2005 that as consumers bid farewell to low-carb diets, new bread products flooded the market emphasizing healthier whole grains and high fiber content. As a result of increased consumer demand for low-carbohydrate breads, Mr. Scott, a manager of a food retail company in the Fargo-Moorhead area, is considering marketing low-carbohydrate bread, but he needs to know the premiums that the low-carbohydrate attribute and other attributes will receive. This case study uses store data in a hedonic pricing framework to determine the value consumers place on the low-carbohydrate attribute and other attributes in breads. Such a framework can be a useful tool for a food retailer who wants to investigate which attributes lead consumers to pay a higher premium.

Results from our study of the Fargo-Moorhead market show that the price premium for low-carbohydrate ranges from $0.47 per loaf of bread in grocery stores to $0.97 per loaf of bread in non-grocery stores. This premium may not only reflect the value for those specifically following a low-carbohydrate diet. Individuals could also value the lower-carbohydrate attribute for other health reasons. Results also suggest that consumers will pay more for smaller serving size, smaller quantity, and lower fat content. Also, despite the price premium for low carbohydrates, consumers are also willing to pay more for higher sugar content. Calories and protein content, on the other hand, are not found to affect consumer willingness to pay. The low-carbohydrate attribute of bread that has small slices and loaf size and is low in fat will command a higher premium. Higher fiber content may also receive a premium in some markets, though it is only marginally significant in this market.

Regional, national, and international trends for low-carb breads (with health attributes from higher fiber content) continue to increase. However, one question that remains is that, since there are no existing regulations permitting the use of carbohydrate claims in foods, how low does the amount of carbohydrates in bread need to be for the producer to market it as such? Furthermore, should an FDA-approved "low-carbohydrate" label be forthcoming, how will that change affect the value of low-carbohydrate foods and the marketing of such? The data show that in this market, the breads marketed as low-carbohydrate averaged 8.8 grams of carbohydrates per serving, while conventional breads averaged 16.7 grams per serving. The descriptive statistics show that the low-carbohydrate designation is appropriate, and that other quality attributes are incorporated into these low-carbohydrate breads to make them high-quality products. Mr. Scott, however, is concerned about the long-run implications for packaging the low-carbohydrate attribute given the lack of a federally recommended definition for low-carbohydrate products.

References

ACNielsen. 2004. "ACNielsen Quantifies Impact Of Low Carb Diets." ACNielsen News Release. Available at http://www.acnielsen.com/news/american/us/2004/20040209.htm

Allan, C. and W. Lutz. 2000. *Life Without Bread: How a Low-Carbohydrate Diet Can Save Your Life*. New Canaan, CT: Keats Publishing.

Alpizar, F., F. Carlsson, and P. Martinsson. 2001. "Using Choice Experiments for Non-Market Valuation." Staff Working Paper, Goteborg University, Department of Economics, Series Paper 52, (June) 3.

Becker, G. S. 1965. "A Theory of the Allocation of Time." *The Economic Journal* 75(September): 493–517.

Benkouider, Christiana. 2004. "Functional bread in Europe—A Niche Market with Potential." *Euromonitor International.* Market Trends Bread.

Bowman, S. A. and J. T. Spence. 2002. "A Comparison of Low-Carbohydrate *vs.* High-Carbohydrate Diets: Energy Restriction, Nutrient Quality and Correlation to Body Mass Index." *Journal of the American College of Nutrition* 21(3):268–274.

Brooker, J. R., D. E. Terry, and D. B. Eastwood. 1986. "Hedonic Pricing of Food Items Based on Nutritive Attributes." *Journal of Food Distribution Research* 17(February):61–68.

Chatterjee S. and B. Price. 1991. *Regression Analysis by Example*, 2nd ed. New York: John Wiley & Sons.

Deaton, A. and J. Muellbauer. 1980. *Economics and Consumer Behavior*. Cambridge University Press: Cambridge, UK.

Dietary Guidelines Advisory Committee. 2004. "*2005 Report of the Dietary Guidelines Advisory Committee*." U.S. Department of Agriculture. Available at http://www.health.gov/dietaryguidelines/dga2005/.

Ekeland, I, J. J. Heckman, and L. Nesheim. 2001. "Identification and Estimation of Hedonic Models." Paper Presented at Sherwin Rosen Memorial Conference, University of Chicago, May 19.

Fargo-Moorehead Yellow Book. "Food Service Distributors," http://www.dexknows.com/displaycontactform.ds?type=visitor. Accessed July 3, 2008.

Grossman, M. 1972. "On the Concept of Health Capital and the Demand for Health." *The Journal of Political Economy* 80(March–April): 223–225.

Kantor, L. S. 1998. "A Dietary Assessment of the US Food Supply: Comparing Per Capita Consumption with Food Guide Pyramid Serving Recommendations." U.S. Department of Agriculture, Economic Research Service, AER-722. December.

Kennedy, P. 1992. *A Guide to Econometrics*, Third Edition. Cambridge, MA: MIT Press.

Lusk, J. L., T. Feldkamp, and T. C. Schroeder. 2004. "Experimental Auction Procedure: Impact on Valuation of Quality Differentiated Goods." *American Journal of Agricultural Economics* 86(May):389–405.

Maguire, K. B., N. Owens, and N. B. Simon. 2004. "The Price Premium for Organic Baby food: A Hedonic Analysis." *Journal of Agricultural and Resource Economics*. 29:132–149.

Mancino, L., B-H. Lin, and N. Ballenger. 2004. "The Role of Economics in Eating Choices and Weight Outcomes." U.S. Department of Agriculture, Economic Research Service, Agricultural Information Bulletin Number 791. September.

Mintel International Group Limited. 2004. "The Bread Market—US 2004." Report/Study Product Ref 26023.

Mokdad, A. H., J. S. Marks, D. F. Stroup, and J. L. Gerberding. 2004. "Actual Causes of Death in the United States, 2000." *Journal of the American Medical Association* 291:1238–1245.

Nayga, R. M., Jr. 1998. "Consumer Characteristics Associated with Low-Fat, Low-Cholesterol Foods." *International Food and Agribusiness Management Review* 1(1):41–49.

Nutrition Business Journal. 2004. "Sports Nutrition & Weight Loss Report 2004." San Diego, CA.

Packaged Facts. 2006. "Bread Products in the U.S." Pub ID LA1209573. 114 pages.

Philipson, T., C. Dai, L. Helmchen, and J. Variyam. 2004. "The Economics of Obesity: A