CONSUMER WILLINGNESS TO PAY FOR BREADS MARKETED AS "LOW-CARBOHYDRATE" BREADS

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CUSTOMER WILLINGNESS TO PAY FOR BREADS MARKETED AS "LOW-CARBOHYDRATE" BREADS

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

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ABSTRACT

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Excess carbohydrate intake is a major cause of obesity, a leading cause of preventable death, in the United States. In this study, a hedonic pricing model on willingness to pay a premium for low-carbohydrate breads was developed. An advantage of hedonic pricing methods over the other economic models is its ease to use over-the-counter data on quantity, price, and other store characteristics, especially in the case of low-carbohydrate breads.

Tradeoffs among price, quantity, and dimensions of quality were estimated when consumers made bread-purchasing decisions. Results indicate that consumers are willing to pay a higher premium for low-carbohydrate breads at various locations and markets. Policy initiatives aimed at providing official definitions for "low carbohydrate" may facilitate marketing of this food.

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CHAPTER 1. INTRODUCTION

1.1. Background

According to the United States Department of Agriculture (USDA) Economic Research Service (ERS), Americans spend about $900 billion on food each year (USDA-ERS, 2004b). A substantial portion of this expenditure is on concentrated sugars and refined starches, which make up the carbohydrate category. The USDA-ERS states that "Per capita use of flour and cereal products reached 200 pounds in 1997 from an annual average of 145 pounds in 1980 and 136 pounds in 1970" (Putnam and Allshouse, 1999, p. 23). The consumption of high-carbohydrate snack foods has also increased by 200 percent.

Excess carbohydrate intake is a major cause of obesity, a leading cause of preventable death, in the United States. Research studies by the Center for Disease Control and Prevention (CDC) measure obesity by the "body mass index" (BMI), a ratio of weight to height of an individual. "An adult who has a BMI between 25 and 29.9 is considered overweight and a BMI of 30 or higher is considered obese" (CDC, 2004a).

The American Obesity Association (AOA) states that obesity is a disease that affects nearly one-third of the adult American population (approximately 60 million). The number of overweight and obese Americans has increased since 1960. Today, 64.5 percent of adult Americans (about 127 million) are categorized as being overweight or obese (AOA, 2002a).

Obesity is the second leading preventable cause of death in the United States (CDC, 2004b). The prevalence of overweight children and adolescents has tripled according to Philipson et al. (2004). Similar trends are occurring in other countries. Obesity is the most common public health concern. The occurrence of obesity in the United States has risen at

an epidemic rate during the past few centuries. In Figure 1, two-thirds of United States adults were overweight or obese in 1999-2002, compared to 56 percent in 1988-1994 (CDC-USHHS, 2004).

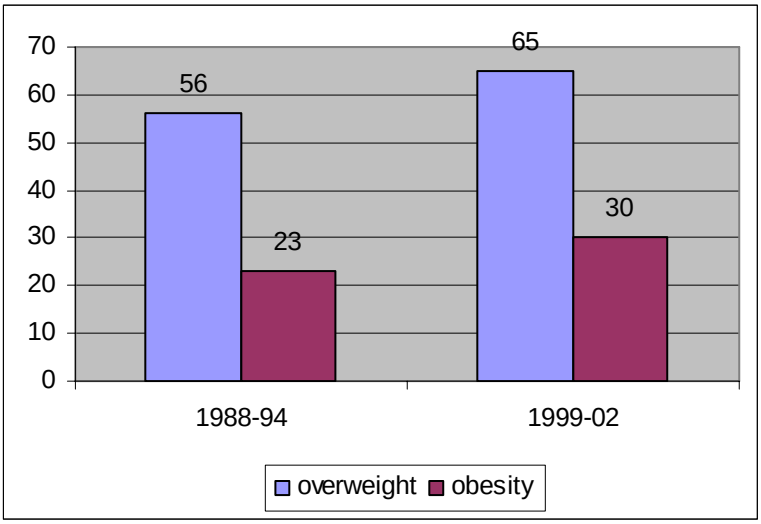

Figure 1. United States Adult Population Trend of Overweight vs. Obese.

Figure 2 illustrates the percentage of overweight males and females in selected countries. The World Health Organization (WHO) estimates that 1.3 billion people globally are overweight or obese (Times and Trends, 2004). Men generally have higher rates in the overweight category, where as women have higher rates of obesity. The chart indicates an estimated 65 percent of the adult population as being overweight in 1999-2002, a nine percent increase from previous years. The United States is ranked competitively higher globally (Times and Trends, 2004).

This global trend of overweight and obesity is also prevalent in children. In a study by Deckelbaum and Williams, they declared that in North America and internationally, approximately 22 million children in the less than 5 years of age category are overweight.

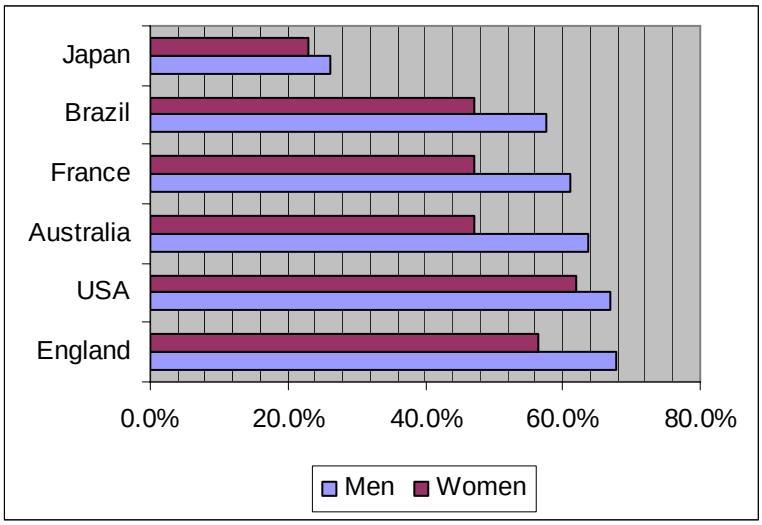

Figure 2. Population Categorized as Overweight.

The study also noted that the number of overweight children and adolescents has doubled in the last two to three decades. Disturbingly, obesity in childhood, particularly in adolescence, is a key predictor for obesity in adulthood (Deckelbaum and Williams, 2001).

Some federal and private initiatives to combat overweight and obesity are changes in the USDA's Food Guide Pyramid and Food Guidelines in 2005. These changes will help make consumers aware and able to recognize the differences between types of carbohydrates. It will also encourage consumption of more unprocessed grains like whole wheat bread with high fiber content. The revised pyramid will "provide consumers with a formula to personalize their diets based on how much they exercise, their age, gender, weight and height" (CBS, 2003). The new guidelines will also advise consumers to set sensible consumption of sugars (carbohydrates) and fats (lipids), the body's two most important sources of energy.

Consumers are becoming more aware of the effect of nutrition on health and some are changing their purchasing habits. The past decade has brought the purchase and

consumption of low-carbohydrate foods to the forefront. In 2003 alone, over 600 low-carbohydrate foods were introduced (Hellmich, 2004). Although the Food and Drug Administration (FDA) have not officially defined the term low-carbohydrate, companies are taking advantage by developing new low-carbohydrate products. These products have lower carbohydrate contents, which are intended to entice customers.

Some researchers believe that obesity and overweight can be reduced with diets low in fat. Several short-term laboratory studies have demonstrated that very low-carbohydrate diets (carbohydrate intake <25 g/d) can substantially reduce metabolism and cause weight loss (Westman et al., 2002). However, the price impacts of low-carbohydrate foods on the consumption of these foods have yet to be analyzed. Economic theory suggests that consumers will purchase more foods at a lower price and pay a premium for foods they perceive as higher quality.

Some studies have examined the long-term effects on the use of low-carbohydrate diets. Bilsborough and Crowe stated that heart arrhythmias, cardiac contractile function impairment, sudden death, osteoporosis, kidney damage, increased cancer risk, impairment of physical activity, and lipid abnormalities can all be linked to long term restriction of carbohydrates in the diet (2003).

1.2. Problem Statement

In a study conducted by Mintel, from 1998 to 2003, the United States bread market sales increased to $16 billion, a growth of 18 percent (Mintel, 2004a). Low-carbohydrate foods constitute approximately $1.41 billion of the estimated $900 billion spent on food by United States consumers in 2003, up 90 percent from 2002 (Baking Business, 2004). Lindeman (2004) noted that the number of consumers on the latest low-carbohydrate diet

trend has held steady between 6-7 percent throughout 2004. Forty percent of adults in the United States, or an estimated 83.6 million people, report that they have reduced their carbohydrate intake (Mintel, 2004b).

Atkins Nutritionals, a market leader in the sales of low-carbohydrate foods more than doubled its annual sales to $200 million in 2002 (Stauffer, 2004). Stauffer also reported sales of low-carbohydrate breads have increased two to thee percent of a 16 billion dollar bread industry (2004).

Sosland (2004) stated that the growth of the low-carbohydrate product category has been both unexpected and strong. Data from Information Resources, Inc. shows that the low-carbohydrate brand line sales increased $518 million in supermarkets, drugstores, and mass merchandisers, excluding Wal-Mart Stores. For the 52-week period ended April 18, 2004, sales increased $32 million compared to December 31, 2000 (Sosland, 2004). Low-carbohydrate food including bread and bread products are a relatively new industry and businesses are still developing strategies to market low-carbohydrate attributes. Additional information about pricing strategies will facilitate better marketing decisions for retailers.

1.3. Objectives and Hypothesis

The main purpose of this paper is to estimate how consumers evaluate tradeoffs among price, quantity, and dimensions of quality when they make bread purchasing decisions. This study examines the effect of product and store characteristics on low-carbohydrate bread and conventional bread in such categories as prices, a wide array of product characteristics as well as store characteristics.

The specific objectives of this study are to

(1) Describe the market for low-carbohydrate bread consumption compared to conventional bread;

(2) Analyze consumer willingness to pay for low-carbohydrate bread;

(3) Determine the marginal impacts of major factors affecting price premiums associated with low-carbohydrate bread; and

(4) Derive implications for short and long run demand trends for the low carbohydrate bread sales.

This study will test the hypothesis that consumers are willing to pay higher premium for low-carbohydrate bread at various locations and markets.

1.4. Methodology

This study uses data collected from retail stores and develops a hedonic pricing model to analyze the price premium paid for low-carbohydrate bread. An advantage of hedonic pricing methods over the other economic models is the ease to use over the counter data on quantity, prices, and other store characteristics, especially in the case of low-carbohydrate bread. The basic premise of the hedonic pricing method is that the price of marketed goods, such as low-carbohydrate bread, is related to its quality and quantity characteristics.

The three characteristics in this study are price, product, and store. Price characteristics are determined from the price of conventional and low-carbohydrate bread, and serving size. Product characteristics are measured using nutrition information: calories, protein, carbohydrates, sodium, and fiber content. Finally, store characteristics

are measured by the type of store and space allocations for the product. Secondary data from grocery stores, Internet, and discount stores are used for the analysis.

The rest of this paper is organized as follows. Chapter 2 includes a brief review of the literature, previous studies of consumer awareness, and acceptance of the low-carbohydrate diet. Chapter 3 includes a discussion of the hedonic pricing method used to estimate willingness to pay. Finally, results and conclusions, including implications for the study, are presented in Chapters 4 and 5.

CHAPTER 2. LITERATURE REVIEW

In this chapter, a review of studies linking obesity and low-carbohydrate products is provided. In later sections, the economic impact of obesity and methods used to reduce obesity is provided. Finally, a description of economic models to quantify consumer's willingness to pay for low-carbohydrate foods is presented.

2.1. Studies on Obesity and Low-Carbohydrate Diets

The United States is relatively young and comprised almost entirely of immigrants, resulting with the American culture lost in a melting pot. To the outside world, the fast food industry might best exemplify the United States diet. In a study conducted by the USDA-ERS, Blisard stated "By 2020, the U. S. population will add between 50 and 80 million people – all becoming part of the food system. U.S. food expenditures are projected to rise 26 percent between 2000 and 2020" (Blisard et al., 2002, p. 2).

Over the last two decades, the occurrence of obesity has increased considerably. The CDC estimated that, in 1999–2000, 31 percent of United States adults (nearly 59 million Americans) were obese (CDC, 2004b). The study also described those categorized as obese as having a greater risk of developing numerous life-threatening health conditions, including type 2 diabetes, osteoarthritis, coronary heart disease, strokes, muscle loss, colon cancer, insulin resistance, breast cancer, gall bladder-disease, and sleep apnea.

Obesity is a health condition largely caused by an increased consumption of high-energy foods: saturated fats and sugars combined with reduced physical activity. Research conducted by the American Obesity Association states that the "tendency toward obesity is fostered by our environment: lack of physical activity combined with high-calorie, low-cost foods" (AOA, 2002b).

Scientific research pertaining to low-carbohydrate food is limited. Foster et al. (2003) conducted a one-year, controlled trial of 63 obese men and women. These subjects were randomly assigned to a conventional diet (low-calorie, high-carbohydrate, low-fat) or a low-carbohydrate, high-protein, and high-fat diet. At three months, subjects on the low-carbohydrate diet lost more weight than those on the conventional diet, but found that there were no significant differences after one year. Longer studies are required to determine the long-term safety and health risks of low-carbohydrate diets.

Westman et al. (2002) determined the effect of a six-month low-carbohydrate diet on body weight of 51 overweight participants. They were given dietary supplements and educated on exercise techniques. Participants also gathered in groups for meetings and support. The outcome for the group was positive with 41 of the 51 participants attending throughout the six-month period. A 10.3 percent mean decrease in body weight with a standard deviation of 5.9 percent and a mean fat decrease of 2.9 percent with a standard deviation of 3.2 percent were revealed. The study concluded that a low-carbohydrate diet program led to sustained weight loss during a six-month period and suggested that additional studies be conducted.

A follow up study by Westman et al. (2002) included 132 severely overweight adults. The research determined the effect of a low-carbohydrate diet on weight and other factors after a one-year period. The researchers assigned patients to either a low-carbohydrate weight loss diet or a conventional low-fat weight loss diet. The researchers collected information about weight at the start of the diet, after six-months, and after one-year.

The study revealed that after one-year subjects on the low-carbohydrate weight loss diet had maintained weight at six-months, compared to those on the conventional weight loss diet who gained weight. Conclusions obtained from a study between six-months and one-year were not significant, and suggested future studies should address the impact of low-carbohydrate diet on the body's cardiovascular condition over a longer period.

Bilsborough and Crowe discussed a potential effect of decreasing bone growth by following a low-carbohydrate diet. The study explained that "low-carbohydrate diets promote the restriction of dietary products, particularly milk and yogurt, which are the main sources of calcium in the diet" (Bilsborough and Crowe, 2003). The study also explains that fruits and vegetables contain a vast array of compounds that are implicated in providing protection against cancer. For example, the nature of low-carbohydrate diets is one that is low in fruits, vegetables, and grains, but followed long term could potentially place an individual at an increased cancer risk.

2.1.1. Changing Food Pyramid

The International Food Information Council Foundation (IFICF) states "obesity has become an increasing public health problem and the driving force of nutrition trends today" (Food Insight, 2004). The study also explained how the Food Guide Pyramid is used in advising proper weight management. However, attention given by the media and other forms of public information gave consumers mixed messages on the proper guidelines of the Food Guide Pyramid, resulting in underutilization.

The United States food system is made up of a variety of food products with different nutrients and other health substances needed for a healthy diet. By eliminating certain food groups from a diet, the body will not acquire nutrients needed to remain

healthy. For example, the USDA-USHHS (United States Health and Human Services) Dietary Guideline for Americans states "oranges provide vitamin C and folate but no vitamin B_{12}; cheese provides calcium and vitamin B_{12} but no vitamin C" (USDA-USHHS, 2000, pg. 14). Given the unlimited abundance of foods available in the United States, the Food Guide Pyramid suggests servings to maintain a healthy diet.

In 1992, the Food Guide Pyramid was developed based on the Dietary Guidelines by the USDA (Heart Center, 2004). The USDA expects the release of the new Dietary Guidelines in early 2005 (USDA, 2004). The Food Guide Pyramid of daily dietary recommendations divides food into six groups. It offers practical advice to enjoy the diverse array of foods available in the marketplace. The top of the pyramid contain foods that should be consumed sparingly, such as fats, oils, and sweets. As the pyramid widens toward the bottom, the milk, yogurt and cheese group, along with the meat, poultry, fish, dry beans, eggs, and nuts group suggest two to three servings per day. The next level contains the vegetable and fruit groups which suggest two to five servings per day. Finally rounding off the bottom of the pyramid is the bread, cereal, rice, and pasta group with suggested servings of six to eleven per day.

As shown in Figure 3, the Food Guide Pyramid suggests that for a healthy diet, consuming a variety of foods that contain protein, vitamins, minerals, and fiber are needed for good health. The Food Guide Pyramid suggests choosing a diet that contains a variety of each food group: grain products, vegetables, dairy, and fruits to provide the needed daily intake of minerals, vitamins, carbohydrates, and fiber. Making sensible choices like a diet low in fat, saturated fat, carbohydrates, and cholesterol will help reduce the risk of obesity, high blood pressure, heart attacks, and certain types of cancer.

2.1.2. Demand Trends of Carbohydrates and Low-Carbohydrate Diets

Carbohydrates come from a wide array of foods, e.g., bread, rice, milk, popcorn, cookies, spaghetti, and corn to name a few. They also come in a variety of forms, but the most common and abundant is sugar, fiber, and starches. The basic building blocks of carbohydrates are sugar molecules. Carbohydrates come in two basic categories: simple and complex. Simple carbohydrates are digested quickly and contain between one and three units of sugar linked together in a single molecule. Examples include fruits, milk, yogurt, and honey, which contain few essential vitamins and minerals. Complex carbohydrates are made up of hundreds of sugar units linked together in a single molecule, and take longer to digest. Complex carbohydrates are found in whole grain breads, cereals, vegetables, pasta, vitamins, and minerals (Healthy Heart, 2004).

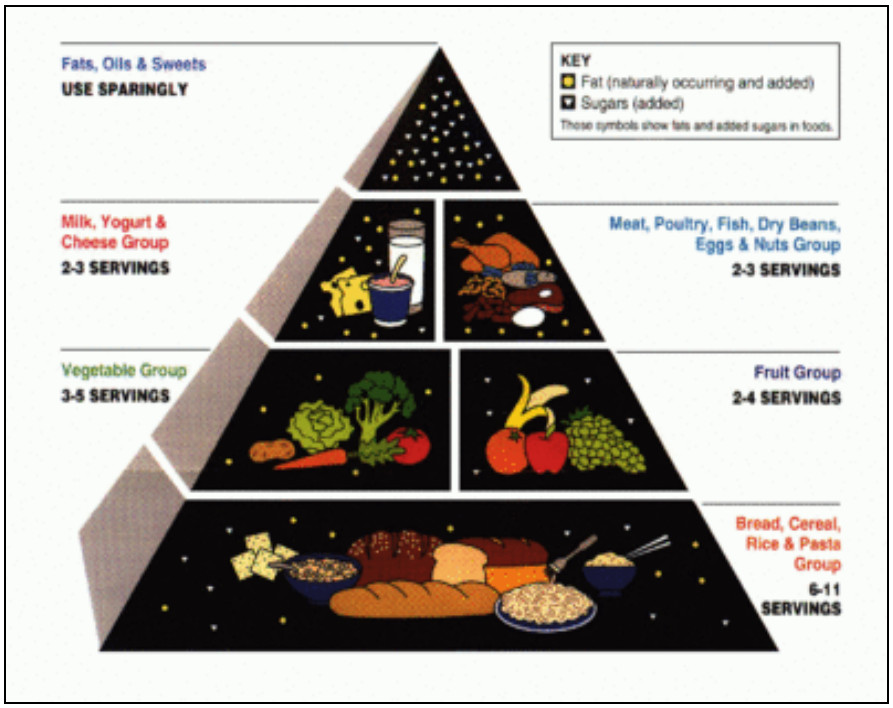

Figure 3. Food Guide Pyramid, Guide to Daily Food Choices. (Wikipedia Free Encyclopedia, 2004).

The Food Guide Pyramid suggests ideal food serving sizes and numbers of servings for a healthy diet. Many dieters are too eager to lose weight. With the vast array of quick loss plans, dieters turn from the healthy style of eating to cutting out a majority of the nutrients the body requires. The basic principle of the low-carbohydrate diet is to reduce the intake of carbohydrates and replace them with increased protein and fiber. If the body is deprived of its main source of energy, it has to burn up its available energy stores of fat. Much is actually water loss, in essence that is how weight is lost. Different versions of the low-carbohydrate diet exist. One popular version is the Atkins New Diet Revolution, which describes an eating plan that includes reduced intake of carbohydrates. Another is the CarbCutter Diet, which is a dietary supplement to assist with a low carbohydrate diet.

In a research study by Mintel, “the low carb trend has played a significant role and will increasingly impact certain industries" (Mintel, 2004b). Companies have had significant success in the expansion of the low-carbohydrate trend. Industries such as General Mills, Kellogg Co., and Sara Lee are marketing products catering to low-carbohydrate dieters. Examples of such products are candies, cereals, salad dressings, and breads.

The sale of low-carbohydrate products has increased from $400 million the beginning of 2002 to $5.9 billion at the end of the year (Johansson, 2003). According to Baking Business, a 30-50 percent increase in sales of the low-carbohydrate products are expected by 2005. Atkins Nutritionals is one of the leading diet companies in the low-carbohydrate industry. In 2002, they doubled their annual sales by making over $200 million. In 2003, Anheuser Busch and Atkins Nutritionals were ranked at the top of low-carbohydrate food and beverage companies (Baking Business, 2004).

The baking industry has a growing demand for low-carbohydrate foods. In the 1970s, a reduced-calorie bread was created. Soy or oat fiber was added, along with proteins, bulking agents, and sweeteners. The sweeteners decrease the sugar and carbohydrate content but still satisfy the flavor consumers desire (Stauffer, 2004).

The bread industry has changed significantly in the last two to three years. According to Baking Business, in 2001, fresh bread was purchased by 98 percent of households, and the average amount spent was $2.09 per loaf of bread. From 2001-2002, the sales of bread increased from $5.94 billion to $6.16 billion (Baking Business, 2002). ACNielsen (2004), a market information provider, tracked categories of conventional and low-carbohydrate foods. They noted that higher carbohydrate foods show a decline in sales, whereas higher protein or low-carbohydrate foods show an increase in sales. Sales of white bread have shown a decrease of 4.7 percent from a year ago while whole grain bread had shown an increase of 4.0 percent.

The extensive change in nutritional behavior caused by the Atkins Nutritional diet, has affected the food industry. An article by the Functional Foods and Nutraceuticals states, "the mass change in dietary habits has affected all aspects of the food industry from the declining sales of potatoes, refrigerated orange juice and instant rice. Protein food groups such as meats and nuts have benefited from the trend. The nuts and dried fruits market grew almost 8 percent from 2002 to 2003, and the meat snacks market, grew 147 percent from 1997 to 2002" (Functional Foods and Nutraceuticals, 2004).

2.1.3. Labeling Low-Carbohydrate Products

Although there has been no official definition by the FDA, labeling of new low-carbohydrate products has become an issue. With manufacturers delivering new products,

an assortment of problems with labeling occur. The problem of labeling low-carbohydrate foods is especially prevalent. Juttelstad states that "any food products labeled as 'low-cab' or as containing, 'only_carbs,' are considered by the FDA to be misbranded under Section 403(r)(1)(A) of the Federal Food, Drug and Cosmetic Act as no nutrient content claim for carbohydrates has been authorized by FDA" (2004).

The FDA regulates health claims in food labels in the United States. Since there is no legal definition for the term "low carbohydrate," manufacturers can put a low-carbohydrate label on any food product they make, therefore misleading consumers (Coleman and Serrano, 2004). Consumers may purchase low-carbohydrate products believing they are healthier, but may actually be high in fat and calories. For example, a low-carbohydrate nutrition bar my have 12 grams of total fat, 7 grams of saturated fat, and 280 calories, where carbohydrates may be substituted for sweeteners, therefore misleading consumers.

2.2. Economic Impact of Obesity and Methods Used to Reduce Obesity

The National Association of Wheat Growers stated that "Obesity has become a leading public health concern as it edges smoking for the leading cause of death killing nearly 400,000 people each year" (National Association of Wheat Growers, 2004). America's food choices and eating habits changed dramatically during the 20th century. Being overweight, obesity, and their associated health problems have a significant economic impact on the United States healthcare system. According to the USDA's Cooperative State Research, Education, and Extension Service (CSREES), in 2000, obesity cost the United States economy an estimated $117 billion (USDA-CSREES, 2004). Connolly (2004) reported that obesity accounted for 27 percent of healthcare spending

from 1987 to 2001. The cost of treating illnesses related to obesity was estimated to be $93 billion.

In the past decade, new foods that are lower in fat and higher in fiber, lower in calories or lower in carbohydrates, have been introduced to the market. Each provides consumers with preferred characteristics such as fat free, low-carbohydrate, and sugar free. Currently, these food groups are undefined by the FDA.

The USDA stated, "Changes over the years in the food choices of individuals affect not only the lifestyle and well-being of American households but also have implications for society that extends far beyond the family dinner table. Changes in food choices and preferences by consumers have meant changes for farmers and the food production and marketing systems, as changing food consumption patterns signal producers as to certain crops to grow and which food to provide. For example, the long term-shift toward eating more chicken instead of beef has led to structural changes in production, such as growing consolidation and vertical integration in poultry production" (USDA-ERS, 2004a). These changes have significant economic implications.

2.3. Prior Studies and Methods Used to Estimate Price Premiums

Low-carbohydrate diets have had a substantial impact on the sales of grain-based foods in supermarkets, restaurants, and other retail outlets since they were first introduced. In the United States, there are many brands of conventional and low-carbohydrate breads available at retail outlets. Examples include Sara Lee Bakery Group, Village Hearth, and Panera Bread who offer both conventional and low-carbohydrate products. Low-carbohydrate breads are sold in major grocery stores in the United States, as well as a select smaller discount stores, and specialty markets.

Convenience and variety have dominated food and beverage growth for years. Consumers have been overwhelmed with information by the national obesity crisis, media attention, and new low-carbohydrate products offered. Consumers evaluate the tradeoff of a number of factors when purchasing low-carbohydrate bread. Decision variables often include price, income, quality, overall availability of the item, and availability of a substitute item, the satisfaction obtained from consumption, perceived freshness, and personal tastes. While searching through display racks of bread, a consumer usually evaluates appearance, features such as the amount, extent of visible defects, and freshness of an item. For many of these attributes, label information, purchasing experience, and the education level of the consumer influence their purchase decision.

The demand for low-carbohydrate diet foods became more receptive to prices as consumers' alternate among other food supplies. In a recent study on Determinants of Food Consumption and Demand conducted by Putnam and Allshouse, "Demand for individual foods is more responsive to prices as consumers substitute among alternative food commodities. Rising incomes increase expenditures on more expensive foods as consumers demand more convenience and quality" (1999). Food prices are determined by the exchanges of demand and supply. In the short run, supplies are relatively fixed. For example, in a quantity-supplied market, supplies go up; price goes down; and consumers buy more.

On the other hand, in the same study by Putnam and Allshouse, "smaller supplies bring higher prices and smaller purchases. In the long run production is adjusted to respond to market prices, producing more of higher priced goods and less of lower priced goods" (1999), assuming production cost is the same for low-carbohydrate bread as to

conventional bread. Long-run changes also reflect a flat demand; technology affects supply and marketing practices in addition to relative prices and incomes of consumers. In addition, demographics are affected; examples are population age and household size. These increases or decreases can cause a change in consumption.

Demand for various desired characteristics may be derived from consumer willingness to pay for a product. Consumers select an item because it possesses the greatest number of desired features for a specified price. However, currently there are no studies on consumer's willingness to pay for low-carbohydrate bread available. A variety of methods to value marketed attributes is available. These methods estimate consumer willingness to pay for product characteristics or attributes. The following is a short description of a few methods that could be applied, their advantages, and disadvantages.

2.3.1. Choice Experiments

Choice experiments examine how an individual makes choices based on the attributes of the product and the level within each attribute. Each alternative of hypothetical products is broken down by specific characteristics or attributes. Price is included as one of the attributes, along with other attributes important to the good, and an opt-out option to ensure that choices are collectively exhaustive. Choosing the best bundle of attributes to make up a product compared to another will provide the most cost efficient combination of attributes for a consumer. Change in price will alter the consumer's willingness to pay for the product. In controlled experiments, sufficient variation in prices, quality, variety, and selection is needed to measure the impact of each attribute on purchase behavior (Alpizar et al., 2004).

Presenting logical and consistent attributes to the survey respondents is one of the most challenging tasks with complex subjects like low-carbohydrate foods and diet. In order to ensure that correct attributes have been presented, focus groups are conducted with experts in the field.

That is, the relationship between prices and each characteristic must be isolated in order to measure the buyer's willingness to pay for each separate attribute. The success of choice experiments depends on the design of the experiment, which is a dynamic process involving definition of attributes, level of attributes, and context of the experiment, along with experimental design and questionnaire development. Focus groups are used to identify attributes and their levels. In this study, breads marketed as low-carbohydrate already exist in the market place, and the complexity of changing dietary preferences may render choice experiments ineffective.

2.3.2. Experimental Auctions

An experimental auction is a method of measuring consumers' willingness to pay for non-marketed commodities. Consumers bid for an auctioned product, and the winner will pay real money for it. Many experimental auctions attempt to gain information on consumer preferences by selling an item that varies by one or two attributes. An advantage of experimental auctions over hypothetical surveys is that it measures more consistency in willingness to pay (VanWechel et al., 2003).

One noted disadvantage in many experimental auctions is the expense, particularly associated with paying participants, and the resulting relatively small sample sizes. This method is also limited in estimating the demand for a product, because it yields several

prices levels for a particular product rather than several price levels for alternative quantity and quality levels of the product.

2.3.3. Survey on Willingness to Pay

A method in measuring the benefit a consumer is willing to pay for an item or service would be to use a willingness to pay survey. For willingness to pay survey, questions are designed to conclude how much an individual is willing to pay for an item or service. However, survey responses lack reliability, validity, and questions concerning willingness to pay for an item or service have been questioned. These surveys can produce biased and unpredictable results.

A disadvantage in willingness to pay surveys is that some respondents may give socially attractive responses to a survey by saying they are willing to pay for more than they actually would if given the chance. Also "willingness to pay" questions wrongly assume that a person who says he/she is "willing to pay" a certain amount than actually has the means to pay.

2.3.4. Hedonic Pricing

In a study conducted by Stavins (2004), it is stated, "hedonic pricing methods are founded on the proposition that people value goods in terms of the bundles of attributes that constitute those goods." Hedonic techniques were traditionally utilized to explain differences in market prices for houses purchased with seemingly similar features (e.g., lot size, square footage, and construction materials) but with variable selling prices. Agricultural analysts have used hedonic techniques to examine why corn buyers preferred corn possessed with certain characteristics to corn with another set of characteristics.

Rosen (1974) defined hedonic prices as the implicit prices of attributes that are discovered by experimental prices and certain number of characteristics of each differentiated product. Estes and Smith (2004) assert, "While hedonic models can provide analysts with useful insights about quality-price relationships, results must be interpreted carefully. Hedonic procedures provide simple equilibrium points where consumers and sellers are mutually satisfied with the exchange price and the set of characteristics and services embodied in the product." Demand for a range of preferred characteristics can result in consumer willingness to pay for that product.

Hedonic price and/or characteristics models are very attractive in analyses pertaining to nutrition issues. Capps and Schmitz (1991) used hedonic model to determine a set of prices for the nutritional characteristics for breakfast cereals and evaluate willingness to pay in a variety of markets. This research highlights the usefulness of the hedonic price technique in the bread industry by evaluating willingness to pay for specific characteristics of conventional and low-carbohydrate bread. Heterogeneity in price and product characteristics offered by a variety of breads enables the creation of estimates of willingness to pay for specific characteristics.

For this paper, the hedonic pricing method was chosen over choice experiments, auction, and surveys because of its ease to use with over-the-counter data on quantity, real price data on marketed goods, and other store characteristics, especially in the case of low-carbohydrate bread. Other methods, like choice experiments, are usually used with products not yet marketed. The hedonic method employed is an inexpensive and straightforward technique for estimating implicit prices.

The base model for this study is a hedonic pricing model adapted from Maguire, Owens, and Simon (2004). Their study asserts that the price premium associated with organic babyfood is estimated by applying a hedonic model to price and characteristic data for babyfood products collected in two cities: Raleigh, North Carolina, and San Jose, California. The price per ounce of baby food is modeled as a function of a number of babyfood and store characteristics. The estimated organic price premium was estimated to be 3¢ to 4¢ per ounce. They concluded that to the extent that this premium reflects consumer willingness to pay to reduce pesticide exposures, and it could be used to infer values for reduced dietary exposures to pesticide residues for babies.

CHAPTER 3. METHODOLOGY AND DATA

3.1. Theoretical Model

The hedonic framework allows estimation of demand for various characteristics of a product offering low-carbohydrate breads. It is statistically based on a multiple regression model that consumers purchase one unit of a differentiated good, **y**, such as a loaf of bread. Bread consists of *n* component characteristics: $y_1, y_2,\ldots,y_n$. These characteristics include the low-carbohydrate characteristics (i.e., low-carbohydrate or conventional), brand, and venues where bread is sold. Consumers maximize utility, *u*, subject to their budget by purchasing one unit of a composite good, *x*, and one unit of the differentiated good, *y*, which has a {1 x *n*} vector of characteristics. That is, consumers maximize $u(x, \mathbf{y})$ subject to a budget constraint, $m = x + p(\mathbf{y})$, where *m* is income and p(y) is the price of bread. Following Maguire, Owens and Simon (2004), the price of the composite good, *x*, 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 as follows:

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

Utility is maximized when the marginal rate of substitution between a characteristic of bread, y_i, and the composite good is equal to the marginal price of y_i. Individuals will consume a characteristic (which is revealed through their purchase of **y**) to the point where the value of that characteristic, or the marginal willingness to pay, is equal to its marginal price. For a given level of income, individuals will choose a loaf of bread with a set of characteristics (e.g., low carbohydrate or fiber content) and pay a price, which will maximize their utility.

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

$$\frac{\partial p}{\partial yi} = \frac{\partial C / \partial yi}{T}, \forall i = 1,...,n, \tag{2}$$

where $\partial C/\partial y_i$ is the marginal cost of producing y_i. In equation 2, the profit-maximizing level of production occurs where the per unit marginal cost of producing a characteristic, y_i, is equal to the marginal price of that component.

From (1) and (2), the following relationship holds:

$$\frac{\partial p}{\partial yi} = \frac{\partial u / \partial yi}{\partial u / \partial x} = \frac{\partial C / \partial yi}{T}. \tag{3}$$

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 production of the characteristic. Therefore, the price of y_i, represents optimal behavior by both sides of the market. This allows one to analyze the price premium for low-carbohydrate bread with prices observed within the market (i.e., posted prices) as opposed to actual transactions.

Rosen (1974) further specifies a bid function, $\theta(y_i; u, m)$, and an offer curve, $\Phi(y_i; \pi, \beta)$, showing the amount consumers are willing to pay and producers are willing to produce, respectively, of a particular y_i; for given levels of utility, income for consumers, profit, and production costs for producers. The tangency between these two curves traces

the hedonic prices function relating the price of a good to its characteristics, $g(y_1,\ldots,y_n)$. In this way, data on prices and store characteristics can be used to estimate the marginal value of one characteristic, holding all others constant.

The relationship between prices and characteristics of bread is estimated as follows:

$$R_j = t(\mathbf{S_j}, \mathbf{O_j}, F_j), \quad \forall\, j = 1,\ldots,J, \tag{4}$$

where R_j is the price of the *i*th gram per slice, $\mathbf{S_j}$ represents a vector of store characteristics for each loaf, $\mathbf{O_j}$ represents a vector of characteristics of the bread other than low-carbohydrate for each loaf, and F_j denotes the low-carbohydrate component of the bread. This analysis is referred to as a first-stage hedonic price function. The derivative of this function with respect to a component price represents a second-stage hedonic price function, which can be used to estimate the demand for a component. However, such estimation would require data on individual consumer characteristics with repeated purchase (Maguire, Owens and Simon, 2004).

Hedonic pricing techniques are utilized to explain differences in market prices for purchases of low-carbohydrate bread. Economists have used hedonic techniques to examine what characteristics provide higher price premiums for a variety of products. Hedonic techniques can provide an estimate for the implied value of each quality-related characteristic in an item such as a low-carbohydrate loaf of bread.

The basic premise of the hedonic pricing method is that the price of a marketed good is related to its characteristics. Therefore, the value of the individual characteristics of a product can be observed by the price people are willing to pay for that characteristic when the characteristics change.

Economic analysts argue that any differentiable product can be described by a vector of objectively measured characteristics embodied in that product. Hedonic modeling efforts rely on the fact that consumers and producers recognize these attributes in approximately the same ways and that the choices each group makes (to demand or supply) lead to equilibrium set of prices.

An advantage of hedonic pricing methods over other economic models is the ease of use of over the counter data on quantity, prices, and other store characteristics. In addition, the hedonic method employed is an inexpensive and straightforward technique for estimating implicit prices.

Another advantage of the hedonic pricing method is that it can be used to estimate values based on actual choices. Data on bread sales and characteristics are readily available through many sources, and can be related to other secondary data sources to obtain descriptive variables for the analysis. The method is versatile, and can be adapted to consider several possible interactions between market goods and product quality.

3.2. Data Collection and Descriptive Statistics

Conventional and low-carbohydrate breads are sold in a number of retail outlets in the United States. These outlets vary from large, regional grocery stores to small specialty shops and convenience stores. No single outlet marketed all types of bread; therefore, different venues were included in the sample. Data were collected in July 2004 at establishments throughout Fargo, North Dakota; Moorhead, Minnesota; and from the Internet. No data were collected on sales promotions during the collection period. Stores in each city were randomly selected from a list of all retail food establishments generated

from current local online consumer yellow pages. Due to the small number, all grocery stores and discount stores were included in the sample.

Table 1 provides a list of descriptive variables that were included within the design of the hedonic model. Characteristics were determined by price, product characteristics and relevant store characteristics. Because Fargo has larger grocery stores and discount stores than Moorhead, the number of observations from Fargo is 466 versus 215 from Moorhead.

Table 1. Description of Variables

Variable	Description
PRICE AND LOW-CARBOHYDRATE VARIABLE	
PRICE	Price per gram
PRICE_CONV	Price per gram of conventional bread
PRICE_LOW	Price per gram of low-carbohydrate bread
LOW-CARBOHYDRATE	1 if low-carbohydrate product, 0 otherwise
PRODUCT CHARACTERICSTICS	
SERVING SIZE	Grams per slice
QUANTITY	Number of slices per package
CALORIES	Calories per serving, grams
SATURATED FAT	Saturated fat per serving, grams
PROTEIN	Protein per serving, grams
CARBOHYDRATES	Carbohydrates per serving, grams
SUGAR	Sugar per serving, grams
FIBER	Fiber per serving, grams
TOTAL FAT	Total fat per serving, grams
CALORIES FROM FAT	Calories from fat per serving, grams
STORE CHARACTERISTICS	
GROCERY	1 if sold in grocery store, 2 if sold in non-grocery, and 3 if sold on Internet
SHELF SPACE (FT)	shelf space devoted to observation
LOCATION	1 if sold in Fargo, ND; 2 if sold in Moorhead, MN; and 3 if sold on Internet.

3.2.1. The Empirical Model

Table 2 summarizes the distribution of visited establishments within the two-city sample and Internet data. Unlike previous analyses using scanner data this study covered all venue types within each city that sold low-carbohydrate breads (e.g. discount stores and Internet), thus providing a more complete representation of the market for low-carbohydrate bread.

Table 2. Distribution of Venues for Low-Carbohydrate Bread by City

Venue Type	Distribution by City				
	Moorhead	(Obs.)	Fargo	(Obs.)	Internet
Grocery Store	4	170	10	369	
Discount Store	3	35	4	62	
Other Store	1	10	2	35	
Number of Observations		215		466	70

Note: Fargo and Moorhead columns contain the number of stores in each location. Obs. is the number of observations at each location. Date of data collection: July 2004.

Store characteristics are measured by the type of store, shelf space in square feet, and location where the observation is collected. A linear model is estimated using equation 5.

$$(5)\quad PRICE_{hij} = \alpha + \beta_1(\text{SIZE}) + \beta_2(\text{QUANTITY}) + \beta_3(\text{CALORIES}) + \beta_4(\text{SATURATED FAT}) + \beta_5(\text{PROTEIN}) + \beta_6(\text{CARBOHYDRATES}) + \beta_7(\text{SUGAR}) + \beta_8(\text{FIBER}) + \beta_9(\text{TOTAL FAT}) + \beta_{10}(\text{CALORIES FROM FAT}) + \beta_n(\text{low-carbohydrate}) + \beta_{11}(\text{SAMPLING SPACE}) + \upsilon_{hij},$$

where $PRICE_{hij}$ is the price per gram of the hth loaf in location i (i.e., Fargo or Moorhead) in store type j (i.e., grocery stores, non-grocery stores, and the Internet), and υ_{hij} is the

random error component. The price per gram, as opposed to the price per loaf, is used as the dependent variable because loaves vary in size according to product specification. Grocery store and non-grocery store variables were not included in equation 5 as they were used to segregate the data.

While bread is widely available in numerous stores, no single store is representative of all available brands, particularly with regard to the low-carbohydrate bread. Internet sales are an important market for low-carbohydrate bread because few retail and grocery stores carry these new products. Hence, it was necessary to obtain data from the Internet in order to obtain a representative and comprehensive sample of low-carbohydrate and conventional breads available for sale.

Data collection resulted in 751 usable observations, with 466 observations from Fargo, 215 observations from Moorhead, and 70 observations from the Internet. Descriptive statistics are provided for the full data set, as well as by store type within location in Table 3. Grocery stores with larger retail brand-name outlets, such as Hornbacher's and Sunmart Foods, are more likely to be similar in size, layout, and familiarity to the customer. The data collected were used to estimate the econometric model.

Descriptive statistics are provided for the full data set. Each variable was measured accordingly: PRICE_CONV (price per gram of conventional bread) and PRICE_LOW (price per gram of low-carbohydrate bread) were measured as continuous variables. Dummy variables were used to differentiate conventional bread (coded as 0) from low-carbohydrate bread (coded as 1). Approximately 25 percent of the observations were low-

Table 3. Descriptive Summary Statistics: Means (Standard Deviations)

		Moorhead		Fargo		Internet
Variable	All Data	Grocery	Non-Grocery	Grocery	Non-Grocery	
PRICES AND LOW-CARBOHYDRSTE VARIABLES						
PRICE per gram	.005	.004	.003	.004	.003	.012
	(.003)	(.001)	(.001)	(.001)	(.001)	(.006)
PRICE_CONV per gram	.004	.004	.002	.004	.003	.005
	(.001)	(.001)	(.001)	(.001)	(.001)	(.002)
	[n=601][a]	[n=132]	[n=54]	[n=310]	[n=84]	[n=21]
PRICE_LOW per gram	.009	.006	.003	.007	.004	.016
	(.006)	(.003)	(.001)	(.003)	(.001)	(.005)
	[n=150]	[n=20]	[n=6]	[n=56]	[n=19]	[n=49]
PRODUCT CHARACTERISTICS						
SERV_SIZE per loaf	31.751	32.522	31.862	32.144	29.489	31.028
	(7.653)	(6.762)	(6.805)	(6.848)	(7.824)	(12.238)
QUANTITY per gram	19.601	19.006	20.419	19.032	24.278	16.700
	(5.663)	(4.212)	(3.272)	(4.373)	(10.170)	(3.427)
CALORIES per gram	79.905	81.633	82.903	79.403	84.123	70.270
	(22.211)	(19.708)	(20.456)	(19.806)	(22.833)	(34.408)
SATURATED FAT per gram	.029	.019	.048	.023	.061	.028
	(.134)	(.097)	(.149)	(.104)	(.242)	(.116)
PROTEIN per gram	3.420	3.300	3.201	3.220	3.314	5.080
	(1.403)	(1.003)	(1.026)	(.958)	(.922)	(2.982)
CARBOHYDRATES per gram	15.133	15.477	16.290	15.186	16.463	11.234
	(4.584)	(3.871)	(3.685)	(3.792)	(4.343)	(7.742)
SUGAR per gram	2.183	2.254	2.282	2.269	2.511	.978
	(1.676)	(1.158)	(.956)	(1.885)	(1.660)	(1.590)
FIBER per gram	1.872	1.830	1.709	1.755	1.866	2.601
	(1.142)	(.985)	(.947)	(.992)	(1.019)	(1.983)
TOTAL FAT per gram	1.019	1.052	1.040	1.000	1.015	1.034
	(.500)	(.425)	(.417)	(.421)	(.626)	(.816)
CALORIES FROM FAT grams	9.838	10.228	10.532	9.769	9.371	8.885
	(5.034)	(3.904)	(7.255)	(3.779)	(7.353)	(6.503)
STORE CHARACTERISTICS						
GROCERY	.938	.960	.403	.994	.392	2
	(.493)	(.194)	(.494)	(.052)	(.445)	(0)

Table 3. (Continued)

		Moorhead		Fargo		Internet
Variable	All Data	Grocery	Non-Grocery	Grocery	Non-Grocery	
NON-GROCERY	.062	.040	.596	.002	.608	0
	(.136)	(.133)	(.494)	(.052)	(.490)	(0)
SHELF SPACE (FT)	2.774	2.894	3.522	3.064	3.000	0
	(3.958)	(5.107)	(3.210)	(3.903)	(2.959)	(0)
OBSERVATIONS	751	152	60	366	103	70

[a]The number of observations, n, is displayed for select variables in brackets. Otherwise, values in brackets are standard deviation.

carbohydrate bread. There were more low-carbohydrate observations in Fargo grocery stores than any other location and market.

Table 3 shows summary statistics. The data consist of prices and low-carbohydrate variables, product characteristics, and store characteristics corresponding to the categories in equation 4. Several variables describe the items or variables in each category. Each location and market derived a mean value; here a brief description of a few variables will be discussed. The mean value, under all data, for SERV_SIZE implies that the average serving size was 31.75 grams. The average serving size for a Moorhead grocery store is 32.52 grams and, for Fargo non-grocery store, is 29.49 grams. Internet mean value was roughly the same with results of 31.03 grams.

The variable QUANTITY had a mean value of 19.60 grams, representing the average number of slices per package. These averages were consistent for Moorhead grocery stores and non-grocery stores, and Fargo grocery stores, but Fargo non-grocery stores had a higher mean of 24.28 grams, and the Internet was significantly lower at 16.70 grams.

CALORIES averaged 79.91 grams per serving for all data. Results were about the same for Moorhead grocery stores and non-grocery stores, but were significantly different in Fargo. Fargo grocery stores averaged 79.40 grams, and non-grocery stores were higher at 84.12 grams. Internet data were considerably smaller at 70.27 grams. The mean for carbohydrates averaged 15.13 grams per serving, which was constant for grocery and non-grocery markets, but was considerably smaller for the Internet at 11.23 grams per serving. The variable FIBER was relatively constant for all data, grocery stores and non-grocery stores across venues, at an average of 1.71-1.87 grams per serving. Internet data were significantly higher at 2.60 grams per serving.

CHAPTER 4. MODEL SPECIFICATIONS AND RESULTS

The theoretical basis for the hedonic model provides little direction on the functional form. Low-carbohydrate bread offerings are assumed to have various characteristics (e.g., price, product, and store), representing a linear relationship in the estimation process. Maguire, Owens and Simon (2004) emphasize that characteristics can vary independently of each other, thus the linear hedonic price function is appropriate.

The estimation process began with the pooling of data across cities and types of stores. The location where the data were collected (i.e., Fargo, Moorhead, and the Internet) and the venue in which bread was sold (i.e., grocery stores, non-grocery stores, and the Internet) were considered separately. In addition, a location by venue dichotomy was created. Non-grocery stores consist of discount stores (e.g., Wal-Mart and Target) and specialty stores (e.g., Harvest Grains and Master Bakery). More observations of low-carbohydrate bread were gathered in Fargo stores than in all other venues because more stores were available in Fargo. Concerns arose that heterogeneity might prevent accuracy with the sub-samples; therefore, the sub-samples were tested separately.

Table 4 shows the results of the F-test for pooling the data across the sub samples based on variability in product prices. Several variables describe the products in each category. In this section, the hypothesis tests that based on product price, the data could be pooled across the defined sub-samples. If homogeneity was confirmed, a single model would be identified and estimated for the complete dataset.

As shown in Table 4, the null hypothesis is rejected across all five models for each of the tests conducted, indicating that the overall data set was heterogeneous, and this heterogeneity was defined both by venue and by location. Therefore, the results were

Table 4. Test Results for Pooling Data

Null Hypothesis	Test Statistic	Degree of Freedom[a]	P Value	Results
FARGO=MOORHEAD=INTERNET	312.65	2: 751	<.0001	Reject Null
INTERNET=FGGR=MHDGR= FGNONGR=MHDNONGR	158.83	4: 751	<.0001	Reject Null
GROC=NON-GROC=INTERNET	317.67	2: 751	<.0001	Reject Null

Notes: The null hypothesis in this paper is that the data from each subsample arise from the same distribution. To test the hypothesis, an F-test was used. FGGR= Fargo Grocery, MHDGR= Moorhead Grocery, FGNONGR= Fargo Non-Grocery, and MHDNONGR= Moorhead Non-Grocery.

[a]The first value represents the numerator degrees of freedom in the F-test, and the second value is the denominator degrees of freedom.

reported by location, as well as by grocery store, non-grocery store, and the Internet. Data from the survey showed that that Fargo and Moorhead prices averaged $0.0044 per gram and $0.0042 per gram, respectively; therefore, the price difference was not statistically significant. The Internet prices were significantly higher at $0.0129 per gram. Also, average prices for non-grocery store ($0.0038 per gram), grocery store ($0.0045 per gram), and the Internet ($0.0129 per gram) were statistically different from each other, with the respective prices shown in increasing order. The Internet data revealed a relatively higher price. The models were estimated using SAS software econometric package.

One important assumption of the classical linear regression model is that the variances of the disturbances or error terms are constant, a phenomenon known as homoscedasticity. If homoscedasticity is rejected the OLS (Ordinary Least Squares) estimator is no longer efficient. White's test was used to test for heteroscedasticity, which subsequently determines whether OLS or Maximum Likelihood Estimator (MLE) would provide consistent parameter estimates. Appendix A shows results of White's Test and Breusch-Pagan Test. An advantage of White's test is that it does not depend as crucially

on normality, nor does it make an assumption about the form of the heteroscedasticity. The disadvantage of using Whites test for heteroscedasticity is that since it does not assume a priori, the form of heteroscedasticity, resulting in a weak test. White's test statistic is asymptotically distributed as a χ^2 with degrees of freedom equal to the number of slope coefficients. Test results are presented in Table 5, and they confirm the presence of heteroscedasticity in the composite dataset, as well in separate datasets for locations Fargo, Moorhead, and the Internet.

Table 5. Results of Tests for Heteroscedasticity

Model	Test Statistic	Degrees of Freedom	P Value	Result
Fargo	393.13	84	0.0001	Reject Null
Moorhead	134.61	80	0.0001	Reject Null
Internet	38.23	46	0.0182	Reject Null
Total	523.72	87	0.0001	Reject Null

Notes: The null hypothesis for each model is homoscedasticity for the error term.

In addition to the heteroscedasticity tests, tests were carried out to investigate another important assumption of the classical linear regression model, normality. Test statistics from Shapiro-Wilk, Kolmogorov-Smirnov, and Cramer-von Mises tests reject the assumption that the error term in our model for the composite dataset follows a normal distribution (Table 6). Under these circumstances, the OLS estimator would not be best linear unbiased, therefore, inappropriate. The MLE approach will provide consistent, asymptotically efficient, and robust parameter estimates; under assumptions of normality MLE is also asymptotically normal.

Table 6. Tests for Normality

	Test		
Test	Statistic	P Value	Results
Shapiro-Wilk	0.8610	<.0001	Reject Null
Kolmogorov-Smirnov	0.1701	<.0100	Reject Null
Cramer-von Mises	5.2740	<.0050	Reject Null

4.1. Model Estimation and Results

The null hypotheses represented in Table 4 were all rejected; therefore, separate datasets were used to estimate equation 5 to account for the different location by venue dichotomies. The additional rejection of the hypotheses in Tables 5 and 6 implied that the OLS estimator would no longer be best linear unbiased. Hence, OLS cannot be used; therefore, the estimation followed the MLE procedure. The MLE procedure provides robust, consistent, and asymptotically efficient estimators which are also asymptotically normal under assumptions of normality.

Table 7 shows the results of five models reported by city and venue. The results will be reported under three core data characteristic sections: low-carbohydrate bread, product characteristics, and store characteristics.

4.1.1. Low-Carbohydrate Variable

One explanation for the study is the estimation of consumers' willingness to pay for low-carbohydrate bread, making this variable particularly important. In the data, low-carbohydrate was coded as a 0-1 variable, with 0 for conventional bread and 1 for low-carbohydrate bread. The low-carbohydrate variables were highly significant at 1 percent in the model representing Fargo grocery stores, and significant at 5 percent in models representing Fargo non-grocery stores, Moorhead grocery stores, and the Internet. The

effect of low-carbohydrate bread is positive, implying the hedonic price is a premium over conventional bread as to low-carbohydrate bread, which will lead to an increase in price.

Table 7. Estimation Results Using Maximum Likelihood Estimator

(dependent variable = Price per Gram)					
	Fargo		Moorhead		Internet
Variable	Grocery	Non-Grocery	Grocery	Non-Grocery	
INTERCEPT	0.01915***	0.00397***	0.01926***	0.00709	0.02466***
	(0.00048)	(0.00148)	(0.00095)	(0.00441)	(0.00482)
LOW-CARBOHYDRATE VARIABLE					
LOW-CARBOHYDRATE	0.00055***	0.00135**	0.00069**	0.00099	0.01148**
	(0.00016)	(0.00052)	(0.00031)	(0.00070)	(0.00231)
PRODUCT CHARACTERISTICS					
SIZE (grams per serving)	-.00020***	-.00005	-.00021***	-7.8×10^{-6}	-.00005***
	(0.00001)	(0.00003)	(0.00002)	(0.00004)	(0.00010)
QUANTITY (per slice/package)	-.00041***	-.00002	-.00044***	-.00016	-.00072***
	(0.00001)	(0.00002)	(0.00002)	(0.00011)	(0.00015)
CARBOHYDRATES (per gram)	-.00012***	0.00007	-.00020***	-.00017	0.00052*
	(0.00004)	(.00010)	(0.00006)	(0.00015)	(0.00028)
PROTEIN (per gram)	-.00017**	0.00016	-.00012	-5.12×10^{-6}	0.00037
	(0.00008)	(0.00019)	(0.00012)	(0.00021)	(0.00031)
CALORIES (per gram)	0.00002***	-.00002	0.00004***	0.00001	-5.32×10^{-6}
	(9.093×10^{6})	(0.00002)	(0.00001)	(0.00003)	(0.00006)
CALORIES FAT (per gram)	-.00001	0.00002	-.00001	0.00015*	-.00009
	(0.00001)	(0.00005)	(0.00001)	(0.00009)	(0.00014)
SATURATED FAT (per gram)	-.00071	0.00079	-.00134*	-.00050	0.00239
	(0.00042)	(0.00069)	(0.00077)	(0.00122)	(0.00426)
SUGAR (per gram)	0.00007***	0.00031**	0.00026***	0.00010	0.0007
	(0.00002)	(0.00012)	(0.00010)	(0.00020)	(0.00048)
FIBER (per gram)	0.00017**	0.00006	0.00021*	0.00035*	-.00006
	(0.00007)	(0.00016)	(0.00011)	(0.00020)	(0.00030)
FAT (per gram)	-0.00041**	0.000115	-.00056**	-0.00120	0.00036
	(0.00016)	(0.00046)	(0.00027)	(0.00086)	(0.00116)

Table 7. (Continued)

STORE CHARACTERISTICS					
	Fargo		Moorhead		Internet
Variable	Grocery	Non-Grocery	Grocery	Non-Grocery	
SHELF SPACE (FT)	-.00007***	-.00008*	-.00004**	2.455×10^{6}	n/a
	(0.00011)	(0.00004)	(0.00001)	(0.00004)	n/a
No. of observations	366	103	152	60	70
Log Likelihood	-4263.7	-591.2	-1696.5	-304.1	-447.2

Notes: *, **, and ***, respectively, denote the statistical significance at the 10 percent, 5 percent, and 1 percent levels. Standard errors are in parentheses.

This conforms to theoretical expectations; low-carbohydrate bread is more expensive than conventional bread. However, in Moorhead non-grocery store model, the low-carbohydrate variable had no significant effect on price. A reason for this could be that fewer selections of low-carbohydrate bread were available in Moorhead non-grocery stores.

4.1.2. Product Characteristics

The amount per serving size coefficient is negative across all markets and locations, and is a highly statistically significant determinant of price in Fargo grocery, Moorhead grocery, and the Internet; therefore, as serving size increases, price decreases. A health-conscious consumer base could prefer thinner slices of bread while holding the opinion that thicker slices are not as healthy. Parameter estimates for Fargo non-grocery and Moorhead non-grocery stores show that serving size is not a statistically significant determinant of price.

The coefficient for Quantity (number of slices per package) is also negative across all markets and locations, and it is not a statistically significant determinant of price (at 1 percent) for Fargo grocery stores, Moorhead grocery stores, and the Internet. The negative signs on the parameter estimates suggest that the price of bread and servings is inversely

related. Therefore, as quantity increases, the price of bread decreases. This may be attributed to the fact that consumers prefer smaller packages of bread. As is the case for serving size, parameter estimates reveal that quantity is not a statistically significant determinant of price.

Parameter estimates for the variable measuring the amount of carbohydrates per serving show mixed results. On one hand, yet in conformity with theoretical expectations, negative and statistically significant variables are obtained for Fargo grocery stores and Moorhead grocery stores. On the other hand, the parameter estimate for the Internet model is positive and statistically significant, albeit at the 10 percent level. This indicates that, as the per serving size of carbohydrate increases, price decreases, and consumers are not willing to pay more for carbohydrates in grocery stores but may be willing to pay more on the Internet. This could be for convenience of shopping, or searching for a particular brand of bread that is not located near the consumer. For data obtained from non-grocery stores in Fargo and Moorhead, the amount of carbohydrate per serving is not a significant determinant of price.

Fargo grocery is the only model in which protein has a significant, even negative effect on price. Therefore, as the amount of protein increases, price decreases. This signifies that protein is not a characteristic that consumers are willing to pay for in bread and consumers may recognize that bread is not a good source of protein. The protein variable is not significant in all the other models.

Data for Fargo and Moorhead grocery stores suggest that the number of calories per serving has a significant and unexpectedly positive effect on price. Although the consumer may desire low calorie bread, the product he/she purchases may not necessarily be priced

to reflect an inverse relationship between price and amount of calories. This may also lead into consumers being misled by low-carbohydrate. The USDA has not approved the definition, therefore, consumers maybe mislead by companies mislabeling products. If the objective of analyzing consumers' willingness to pay for calories involved a canvassing of opinion from the consumer, the results might have been different. Data from the non-grocery stores and the Internet indicated that the amount of calories per serving was not a significant variable.

Yet another variable included in the model is that defined as calories from fat, and it is only statistically significant (at 10 percent) in the Moorhead non-grocery store model. The positive sign is unexpected, yet may be related to the overall movement of total calories with respect to price. In the other models, this variable is not a significant determinant of price.

Results for saturated fats show that the variable is a significant (at 10 percent) determinant of price in the Moorhead grocery store model. The negative sign suggests that price declines as the amount of saturated fats increases. Parameter estimates for this variable in the other models were not statistically significant.

Sugar coefficients were positive and statistically significant across the Fargo markets and the Moorhead grocery store model. This implies that consumers may be willing to pay for a sweeter taste. Results for the Internet and Moorhead non-grocery store models show that parameter estimates were not significant.

The parameter estimates for fiber are positive and statistically significant for the Moorhead market models and the Fargo grocery store model. Fiber significantly increases

price and consumers are willing to pay a premium for fiber in their bread. Fiber is not a significant variable in the Fargo non-grocery store and the Internet models.

For total fat, parameter estimates are negative and statistically significant for the Fargo and Moorhead grocery store models. This implies that, as total fat increases, the price of bread decreases. This variable is not significant in the other models.

4.1.3. Store Characteristics

Each product is given a certain area for shelf space; for example, discount brands sell at a lower price and tend to have larger quantities; therefore, they, respectively**,** have more shelf space, whereas name brand breads are priced higher and, respectively, have less shelf space with fewer loaves. The parameter estimates for the variable defining total space allowed for a product were negative and statistically significant for the Fargo models and the Moorhead grocery store model.

4.1.4. Implicit Price of Low-Carbohydrate Breads

Results show a significant and positive parameter estimate for the low-carbohydrate bread and other desirable variables, such as the amount of fiber, in nearly all venues. The positive sign indicates positive willingness to pay or a premium for that attribute. 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, Table 7 shows consumers are willing to pay a premium for low-carbohydrate bread, ranging from 0.06¢ per gram in Fargo grocery stores to 1.1¢ per gram on the Internet, above the price of conventional bread. Similarly, the implicit price of fiber can be calculated, for example, as

approximately 0.02¢ per gram in Fargo grocery stores and 0.04¢ per gram in Moorhead non-grocery stores.

4.2. Implications

In this study, an estimate was made of the price premium associated with consumer willingness to pay for low-carbohydrate bread. This was done by applying a hedonic model to product and store characteristics. Data for low-carbohydrate bread products were collected from two cities: Fargo, North Dakota, and Moorhead, Minnesota. The price per gram of low-carbohydrate bread as the dependent variable and control for a number of product characteristics (e.g., carbohydrates per gram, calories per gram, and fiber per gram) as well as store characteristics (e.g., type of retail establishment).

The price premium associated with the product characteristic reflected consumers are willing to pay a premium for low-carbohydrate bread ranging from about 0.06¢ per gram in Fargo grocery stores, to 1.1¢ per gram on the Internet, above the price of conventional bread. To the extent, this premium reflects consumers preferences regarding low-carbohydrate bread, these results could be paired up with risk data on obesity or diabetes to estimate the value of the health benefits associated with reduced carbohydrate.

CHAPTER 5. SUMMARY AND CONCLUSIONS

ACNeilson described in recent research that interest in low-carbohydrate foods is showing up in many product categories, with numerous inherently high-carbohydrate foods showing sales declines and many low-carbohydrate and high-protein foods showing sales increases (ACNielsen, 2004). With attention focused on low-carbohydrate diets, the future of food choices will have implications on the structure of the food industry and for the economic advancement of farmers, retailers, and other participants within the food production system.

This study estimated how consumers (particularly, low-carbohydrate consumers) value low-carbohydrate bread. Overall, consumers are willing to pay from 0.06¢ to 1.1¢ per gram more for low-carbohydrate bread as compared to conventional bread. Even though consumption of low-carbohydrate bread is increasingly mainstream, consumers will continue to pay a premium for this product.

The premium for low-carbohydrate bread may also reflect the value associated with the role in a low-carbohydrate diet for weight loss. Individuals could value the purchase of low-carbohydrate bread for others reasons, such as lowering cholesterol. Retail data could not differentiate the effects on consumers nor could cost be chosen. In this case, one can only assert that the premium reflects a desire to eat healthier.

5.1. Future Perspectives

This study opens many possibilities for future studies. Examining how product offerings, marketing, and promotion strategies will change after the FDA defines low-carbohydrate products would make an interesting study.

Another area of interest for future research could be the effect on grain prices. A vast number of consumers are watching their carbohydrate intake; in an article by ArgiMarketing, it was reported that 40 percent of Americans are consuming less bread than the previous year by substituting with low-carbohydrate products. In addition, per capita flour consumption dropped to about 10 pounds per year. This new low-carbohydrate trend has grain producers concerned (AgriMarketing, 2004).

With interest around Atkins, South Beach, and other low-carbohydrate diets in recent years, scientists could look at developing new wheat and barley varieties with unique profiles for a range of food, animal feed, and industrial uses. These new varities would be enhancing health benefits, aiding in the battle of overweight, obesity, and opening doors to new market potential (Western Grains, 2004).

The information from this study is particularly interesting because this information, combined with other low-carbohydrate food information, generated over longer periods, can link this trend to obesity, diabetes, cardiovascular diseases, or chronic disease. A more in-depth study could include a larger geographical region, for instance, a low-carbohydrate store in a largely populated area of Nevada, would sell a variety of low-carbohydrate foods to a specific group of consumers.

5.2. Limitations of Study

The sample group was limited to grocery stores and non-grocery stores with in the Fargo-Moorhead area. Since low-carbohydrate bread is considered a newer low-carbohydrate food item, smaller grocery stores and convenience stores, respectively, do not carry a large selection of low-carbohydrate bread around the Fargo-Moorhead area.

REFERENCES CITED

ACNielsen U.S. (2004, February 9). ACNielson Quantifies Impact of Low Carb Diets. Retrieved November 8, 2004, from http://www.acnielsen.com/news/american/us /2004/20040209PF.htm

AgriMarketing.com (2004, February). Bread Industry Ready to Rise to the Challenge. Retrieved November 16, 2004, from http://www.agrimarketing.com /show_story.php?id=23516

Alpizar, F., F. Carlsson, and P. Martinsson (2001, June). Using Choice Experiments for Non-Market Valuation. Staff Working Paper, Goteborg University, Department of Economics, Series Paper. Retrieved June 9, 2004, from http://web.idrc.ca/uploads/user-S/10301141930choiceexperiments.pdf

American Obesity Association (2002a). Obesity in the United States. Retrieved October 18, 2004, from http://www.obesity.org/subs/fastfacts/obesity_US.shtml

American Obesity Association (2002b). What is Obesity? Retrieved October 18, 2004, from http://www.obesity.org/subs/fastfacts/obesity_what2.shtml

Baking Business.com (2002, July 1). Grain-Based Foods Statistics: Bread. Retrieved September 14, 2004, from http://www.bakingbusiness.com/co_article. asp?ArticleID=45342

Baking Business.com (2004, August 15). Low Carb Sales Trends and Consumer Attitudes. Retrieved September 14, 2004, from http://www.bakingbusiness.com/ co_article.asp?ArticleID=72022

Bilsborough, S. A., and T. C. Crowe (2003). Low-Carbohydrate Diets: What are the Potential Short and Long-Term Health Implications. *Asia Pacific Journal Clinical Nutrition,* 12(4), 396-404.

Blisard, N., B. Lin, J. Cromarite, and N. Ballenger (2002). America's Changing Appetite: Food Consumption and Spending to 2020. United States Department of Agriculture- Economic Resource Services – Food Review. Retrieved April 16, 2004, from http://www.ers.usda.gov/publications/FoodReview/ May2002/frvol25i1a.pdf

Capps, O., Jr., and J. D. Schmitz (1991, July). A Recognition of Health and Nutrition Factors in Food Demand Analysis. *Western Journal of Agricultural Economics,* 16(1), 21-35. Retrieved April 12, 2004, from http://agecon.lib.umn.edu/cgi-bin/pdf_view.pl?paperid

CBS News (2003, September 10). Rebuilding the Food Pyramid. Retrieved October 12, 2004, from http://www.cbsnews.com/stores/2003/07/23/health/printable564688.shtml

Center for Disease Control – National Center for Chronic Disease Prevention and Health Promotion (2004a, June 24). Overweight and Obesity: Defining Overweight and Obesity. Retrieved October 18, 2004, from http://www.cdc.gov/nccdphp/dnpa/obesity/defining.htm

Center for Disease Control – National Center for Chronic Disease Prevention and Health Promotion (2004b, June 24). Overweight and Obesity: Economic Consequences. Retrieved October 18, 2004, from http://www.cdc.gov/nccdphp/dnpa/obesity/economic_consequences.htm

Center for Disease Control – United States Health and Human Services, National Center for Health Statistics (2004, October 6). Prevalence of Overweight and Obesity Among Adults: United States, 1999-2002. Retrieved October 21, 2004, from http://www.cdc.gov/nchs/products/pubs/pubd/hestats/obese/obse99.htm

Coleman, M. D., and E. Serrano (2004). The Low-Carbohydrate Craze: Is it a Healthy Way to Lose Weight? Human Nutrition Foods and Exercise, Publication 348-351, Virginia State University, Virginia Cooperative Extension.

Connolly, C. (2004, October 20). Obesity Gets Part of Blame for Care Costs. *Washington Post*. Retrieved November 28, 2004, from http://www.washingtonpost.com/wp-dyn/articles/A46123-2004Oct19.html

Deckelbaum, R. J., and C. L. Williams (2001). Childhood Obesity: The Health Issue, Obesity Research. Retrieved October 10, 2004, from http://www.obesityresearch.org/cgi/content/abstract/9/suppl_4/S239

Estes, E. A., and V. K. Smith (1996, October). Price, Quality, and Pesticide Related Health Risk Considerations in Fruit and Vegetable Purchases: An Hedonic Analysis of Tucson, Arizona Supermarkets. *Journal of Food Distribution Research,* 27(3), 59-70. Retrieved August 12, 2004, from http://agecon.lib.umn.edu/cgi bin/pdf_view.pl?paperid=3165&ftype=.pdf

Food Insight (2004, July). Pulse Check on Dietary Guidance in the United States. International Food Information Council. Retrieved November 4, 2004, from www.ific.org/foodinsight/2004/ja/guidancefi404.cfm

Foster, G. D., H. R. Wyatt, J. O. Hill, B. G. McGuckin, C. Brill, S. Mohammed, P. O. Szapary, D. J. Rader, J. S. Edman, and S. Klein. (2003, May 22). A Randomized Trial of a Low-Carbohydrate Diet for Obesity. *The New England Journal of Medicine*, 348(21), 2082-2090. Retrieved October 15, 2004, from http://content.nejm.org/cgi/content/abstract/348/21/2082

Functional Foods & Nutraceuticals (2004, May). Americans Willing to Pay More to Cut Carbs. Retrieved September 20, 2004, from http://www.ffnmag.com/asp/articleDisplay.asp?strArticleId=476&strSite=FFNSite

Healthy Heart Beats (2004, April 20). Dining a la Health: Carbohydrates: Simple or Complex? Colorado State University Cooperative Extension. Retrieved May 3, 2004, from http://www.ext.colostate.edu/pubs/healthyheart/0403-04e.html

Heart Center Online (2004). Food Guide Pyramid. Retrieved November 11, 2004, from http://www.heartcenteronline.com/myheartdr/common/artprn_rev.cfm?filename=&ARTID=629

Hellmich, N. (2004, May 5). Low-Carb Buyer, Beware. *USA Today*. Retrieved July 28, 2004, from http://www.usatoday.com/life/lifestyle/2004-05-05-low-carb-treats_x.htm

Johansson, C. (2003, October 10). High Times Hit for Low-Carb Diet Trend. *Billings Gazette.* Retrieved September 14, 2004, from http://www.billingsgazette.com/index.php?id=1&display=rednews/2003/10/22/build/health/46-carbs.inc.

Juttelstad, A. (2004, January). Carbohydrates: How to Reduce, Eliminate, Restructure and Label. *Baking Management*. Retrieved July 8, 2004, from http://www.baking mamagement.bakery-net.com/article/6521.=11475&ftype=.pdf

Lindeman, T. F. (2004, November 9). Amid Signs Fad Fading, Del Monte Unveils Fruit Low in Carbs. *Pittsburg Post-Gazette.* Retrieved November 25, 2004, from http://www.post-gazette.com/pg/04314/408900.stm

Maguire, K. B., N. Owens, and N. B. Simon (2004). The Price Premium for Organic Babyfood: A Hedonic Analysis. *Journal of Agricultural and Resource Economics*. 29(1), 132-149.

Mintel (2004a, February). Bread. Retrieved August 12, 2004, from http://the-infoship.com/study/mt18275_bread_us.html

Mintel (2004b, May). Low Carb. Retrieved September 14, 2004, from http://the-infoship.com/study/mt19858_low_carb_us.html

National Association of Wheat Growers (2004, June 4). Goverment [sic] Reform Committee Holds Obesity Hearing - While Obesity Summit Elevates Debate. Retrieved October 18, 2004, from http://www.wheatworld.org/html/news.cfm?ID=587

Philpson, T., C. Dai, L. Helmchen, and J. Variyam (2004, May). The Economics of Obesity: A Report on the Workshop Held at USDA's Economic Research Service. Publication No. E-FAN 04004. Retrieved October 25, 2004, from http://www.ers.usda.gov /publications/efan04004/

Putnam, J. J., and J. E. Allshouse (1999, April). Food Consumption, Prices, and Expenditures, 1970-97. United States Department of Agriculture, Economic Resource Services. Retrieved November 12, 2004, from http://www.ers.usda.gov /publications/sb965/

Rosen, S. (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy*, 82(1), 34-55.

Sosland, M. (2004, July 6). Low Carbohydrate Boom. Retrieved October 10, 2004, from http://bakingbusiness.com/co-article.asp?ArticleID=71595&PF=print

Stauffer, C. E. (2004, September 14). The Truth About Carbohydrates. *Baking Business*, 37-45.

Stavins, R. N. (2004, December 23). Environmental Economics. Regulatory Policy Program Working Paper. Retrieved December 27, 2004, from http://www.ksg. harvard.edu/cbg/research/rpp/RPP-2004-13.pdf

Times and Trends (2004, August). A Snapshot of Trends Shaping the CPG Industry. Retrieved September 18, 2004, from http://www.gmabrands.com/publications/ gmairi/2004/August/august.pdf

United States Department of Agriculture (n.d.). Backgrounder, Revisions of the Food Guidance System. Retrieved November 12, 2004, from http://www.cnpp.usda .gov/pyramid- update/FGPpercent20docs/Backgrounderpercent20on percent20FGSpercent20Julypercent2012percent2020041ejhpercent20_8_.pdf

United States Department of Agriculture - Cooperative State Research, Education, and Extension Service (2004, October 8). Obesity and Health Weight. Retrieved October 26, 2004, from http://www.csrees.usda.gov/ProgViewOverview. cfm?prnum=2436

United States Department of Agriculture - Department of Health and Human Services (2000). Dietary Guidelines for Americans. Retrieved August 16, 2004, from http://www.usda.gov/cnpp/DietGd.pdf

United States Department of Agriculture - Economic Research Service (2004a, August 23). Diet and Health: Overview. Retrieved October 27, 2004, from http://www.ers.usda.gov/Briefing?DietAndHealth?overview.htm

United States Department of Agriculture, Economic Research Service (2004b, March 21). Food Market Structures: Food Services. Retrieved June 2, 2004, from http://www.ers.usda.gov/Briefing/FoodMarketStructures/producemarkets.htm

VanWechel, T., C. J. Wachenheim, E. Schuck, and D. K. Lambert (2003, May). Consumer Valuation of Genetically Modified Foods and the Effect of Information Bias. Agribusiness and Applied Economics Report No. 513. Fargo: North Dakota State University, Department of Applied Economics.

Western Grains Research Magazine (2004, December). Cashing in on Carbs. Retrieved December 5, 2004, from http://www.westerngrains.com/n_researchMag /rm_0412a.html

Westman, E. C., W. S. Yancy, J. S. Edman, K. F. Tomlin, and C. E. Perkins (2002). Effect of 6-month Adherence to a Very Low-Carbohydrate Diet Program. *American Journal of Medicine,* 113 (1), 30-36. Retrieved November 2, 2004, from http://www.sciencedirect.com/science/dfind?

Wikipedia Free Encyclopedia (2004, September). Retrieved October 16, 2004, from http://en.wikipedia.org/wiki/Food_pyramid#USDA

APPENDIX A. RESULTS OF WHITE'S TEST AND BREUSCH-PAGAN TEST

Number of Observations: 751
Location: All Locations

Parameter	Estimate	Standard Error	P value
Size	-0.00022	0.000019	0.0001
Quantity	-0.00026	0.000021	0.0001
Calories	0.000058	0.000016	0.0004
Saturated Fat	-0.00091	0.000671	0.1734
Protein	0.000681	0.000097	0.0001
Carbohydrate	-0.00033	0.000070	0.0001
Sugar	0.000108	0.000062	0.0823
Fiber	0.00036	0.000100	0.0004
Total Fat	0.000274	0.000281	0.3297
Calories from Fat	-0.00007	0.000025	0.0044
Ft.	-0.001	0.000022	0.0001
low-carbohydrate	0.0001741	0.000333	0.0001
Test for Heteroscedasticity			
	Statistic	DF	P value
Whites Test	523.7	87	0.0001
Breusch-Pagan	223.5	12	0.0001

Number of Observations: 466
Location: Fargo

Parameter	Estimate	Standard Error	P value
Size	-0.00019	0.000598	0.0001
Quantity	-0.00022	0.000015	0.0001
Calories	0.000054	0.000013	0.0001
Saturated Fat	-0.00016	0.000439	0.7151
Protein	-0.00002	0.000109	0.8895
Carbohydrate	-0.00017	0.000056	0.0023
Sugar	0.000138	0.000037	0.0002
Fiber	0.000448	0.000089	0.0001
Total Fat	-0.00021	0.000215	0.3400
Calories from Fat	-0.00006	0.000019	0.0016
Ft.	-0.00009	0.000016	0.0001
low-carbohydrate	0.000695	0.000236	0.0034
Test for Heteroscedasticity			
	Statistic	DF	P value
White Test	393.1	84	0.0001
Breusch-Pagan	146.6	12	0.0001

Number of Observations: 215
Location: Moorhead

Parameter	Estimate	Standard Error	P value
Size	-0.00018	0.000018	0.0001
Quantity	-0.00043	0.000022	0.0001
Calories	0.000039	0.000013	0.0038
Saturated Fat	-0.00124	0.000655	0.0600
Protein	-0.00014	0.000110	0.2095
Carbohydrate	-0.0002	0.000060	0.0013
Sugar	0.000246	0.000091	0.0073
Fiber	0.000221	0.000102	0.0308
Total Fat	-0.00053	0.000251	0.0377
Calories from Fat	-4.42E-6	0.000017	0.7904
Ft.	-0.00003	0.000015	0.0225
low-carbohydrate	0.000702	0.000287	0.0153

Test for Heteroscedasticity

	Statistic	DF	P value
White Test	134.6	80	0.0001
Breusch-Pagan	56.56	12	0.0001

Number of Observations: 70
Location: Internet

Parameter	Estimate	Standard Error	P value
Size	-0.0005	0.000105	0.0001
Quantity	-0.00072	0.000158	0.0001
Calories	-5.32E-6	0.000062	0.9322
Saturated Fat	0.002394	0.00426	0.5766
Protein	0.000373	0.000314	0.2400
Carbohydrate	0.000523	0.000289	0.0756
Sugar	0.000703	0.000481	0.1497
Fiber	-0.00006	0.000301	0.8330
Total Fat	0.000365	0.00116	0.7544
Calories from Fat	-0.00009	0.000144	0.5220
low-carbohydrate	0.01482	0.00231	0.0001

Test for Heteroscedasticity

	Statistic	DF	P value
White Test	68.26	46	0.0182
Breusch-Pagan	7.23	11	0.7799