# NERLOVIAN HEDONIC MODELS FOR THREE DIFFERENT CONTAINER SIZES OF FLUID MILK

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## ABSTRACT

This study applied the Nerlovian quantity-dependent hedonic model to the estimation of hedonic prices of fluid milk by quart, half-gallon and gallon container sizes. The characteristics for all three-container size models were fat content, container type, and brand designation. It is shown that the interpretation of the quantity dependent model is quite different from the conventional price-dependent hedonic model. While each model ascertains consumer willingness to pay for the characteristics of a given good, the ceteris paribus assumptions are different resulting in conditions where the valuation of those characteristics differed in magnitude and /or sign.

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## Introduction

The literature is full of demand studies on fluid milk. Many of these studies use demand systems or single-equation models to derive elasticity estimates for price/quantity relationships, income, and in some cases advertising expenditures. While elasticity measures are invaluable in describing price relationships among goods and in giving economic analysts a description of the inter-workings of a market, they fail to explain the value of the individual components or attributes of a particular good. To understand how consumers value a commodity requires further understanding, such as the identification and valuation of the commodity's components, attributes or characteristics. Hedonic price estimation is the method typically used to estimate the value of the characteristics that make-up a commodity (Waugh).

Given that the study is to be performed on retail scanner data, the assumption that consumers are price takers is consistent with Nerlove's hypothesized polar case two, wherein the dependent variable in the hedonic model are quantities in lieu of prices. In this light a series of quantity dependent hedonic models are used to determine the valuation of the characteristics of white milk for three different container sizes, gallons, half-gallons and quarts. The hedonic models provide information relative to attributes of brand type, container type, and milk fat type for consumers of milk. Knowledge of this type provides information that could allow decision makers to be more precise about adjustments of characteristics and in the development of more comprehensive production, pricing, and advertising strategies.

The dairy industry and companies within the food industry spend millions of dollars annually to promote milk and milk products both generically and proprietarily. It is both logical and timely to consider the effects that the interaction of milk fat type, brand type, and container type, by container size, have on the intrinsic value placed by consumers. This knowledge leads to a better understanding of consumer behavior and make it possible for stakeholders to make better and more informed decisions about production and promotion decisions. However, it should be noted that, to date no one has estimated hedonic models for any of these attributes of white (unflavored) milk.

**Literature**

By identifying the marginal implicit price that consumers place on attributes, manufacturers would be able to discern the relevant characteristics and the effect these characteristics have on the valuation of their product. However, the method of determining marginal implicit price is complicated by identification problems. This fact has been addressed in the literature and raises some theoretical and econometric challenges, which further motivate the timeliness and need for this analysis.

Depending on the conditions of the price discovery process, close attention to the economic theory and the econometric implementation of that theory becomes paramount to interpretation and implication of the estimated coefficients of the hedonic models. Just as Working showed the simultaneous nature of supply and demand requires close attention to econometric detail to correctly identify demand or supply relationships so, Rosen has shown that hedonic estimation requires similar close attention. It was Nerlove who pushed Rosen's work further and identified two simple cases when estimation was possible without the complication of identification problems.

The first known use of a hedonic type of model was that of Frederic V. Waugh, who first applied it in 1927 to a market study of three different vegetables. Waugh recognized that there was a statistical relationship among characteristics or attributes of the vegetables, i.e. color, stem length etc,. and the prices they brought at auction. Waugh, who had limited computational equipment, estimated what he called coefficient of variation from several regressions equations. Unfortunately for Waugh his application had some econometric discrepancies. However, his main premise has proved to be useful for many different applications. Ernst R. Brendt provides a complete explanation of the econometrics Waugh used in his original papers.

Almost a decade after Waugh's work, Andrew Court, who coined the phase hedonic, applied this same theory to automobile prices to adjust the price index for automobiles in an effort to prevent government intervention in the auto industry (Goodman). But it was not until over twenty years after Court's work that hedonic price models gained real notoriety. It was Zvi Griliches who applied them to indexes in 1961 which was instrumental in pushing this type of model into the toolboxes of economists (Brendt). Griliches was able to grasp the economic significance and power behind the hedonic concept and then demonstrate its practical application. Griliches' applications of the hedonic methods were generally applied to adjusting for changes in characteristics of similar items through time. This concept is very much associated with indices. Through his work, the ever-occurring changes that persist as a result of technology can be adjusted for by hedonic application to indices. This procedure is now commonly applied for both demand and supply work.

Many different applications of the hedonic modeling process are used in many fields of economics. One of the most common uses of hedonics is to recover price information where no explicit market information is available. Hedonics are used in the valuation of resources (Goodman) as well as many others including the valuation of fresh tomato characteristics (Jordan et al.), and many other applications too numerous to list.

Further developments and improvements to the hedonic process have continued to come forth. In his 1974 paper Rosen verifies that the identification problem is not just limited to supply and demand models but extends to hedonic price models. Nerlove, in his 1995 *European Economic Review* article, recognizing the identification problem brought to light by Rosen, identifies two interesting conditions associated with identification. Nerlove follows through on the theoretical underpinnings that are implied by price exogeneity and derives a new method for estimating hedonic price models, quite different from the traditional or Waughian hedonic estimation process. Since Nerlove's original work, very few papers have capitalized on the theoretical underpinnings he set forth.

For whatever reason, Nerlove's main point, the validation of hedonic price estimates as being directly tied to the processes that generate the estimates, has been ignored. It is the intention of this paper to revisit the issue by estimating the hedonic models based on Nerlove's guidelines and to present those estimates as being appropriate for scanner data. Whereas Nerlove's data required many assumptions to justify the use of his particular data set, scanner data provided by ACNielsen is retail in nature and requires very few assumptions to implement Nerlove's hedonic methodology.

**General Data Description**

Scanner data have been available from grocery stores since the mid 1970's. The first published academic research to appear using store-collected scanner data appeared in 1987. Scanner data has many different forms. The two primary suppliers in U.S. for scanner data are, aside from proprietary sources, Information Resources Incorporated (IRI) and ACNielsen (Bucklin and Gupta). Scanner data have several different forms. Daily information, as used by Kinoshita et al., in their study of the Japanese milk market, is not often used. Weekly scanner data, the most commonly used frequency, is generally a time-series data set (Bucklin and Gupta). The home scan type of data, which is a survey of household purchases for a specified period, generally a year, is another type of scanner data, although found less frequently in the literature. The type of data used in this work is of the home scan type as collected by ACNielsen.

The 1999 Nielsen home scan data are unique in that this data set is similar to a survey. Each panelist was supplied with a scanner device that he/she used at home to record items purchased at the grocery store, or other types of stores throughout a given time period. Each panelist represents a unique household, with each household having eighteen known demographic characteristics. A complete list of the demographics variables can be reviewed in Table 1.

**Table 1. Demographic Information Available on Households**

| | Demographic Information | Number of categories |
|---|---|---|
| | Panelist ID Number | |
| 1 | Household Size | 9 |
| 2 | Household Income | 16 |
| 3 | Age of Female Head | 10 |
| 4 | Age of Male Head | 10 |
| 5 | Age and Presence of Children | 8 |
| 6 | Male Head Employment | 5 |
| 7 | Female Head Employment | 5 |
| 8 | Male Head Education | 7 |
| 9 | Female Head Education | 7 |
| 10 | Martial Status | 5 |
| 11 | Male Head Occupation | 12 |
| 12 | Female Head Occupation | 12 |
| 13 | Household Composition | 8 |
| 14 | Race | 4 |
| 15 | Hispanic Origin | 2 |
| 16 | Region | 4 |
| 17 | Scantrack Market Identifier | 53 |
| 18 | Projection Factor | 1 |

The households are representative of 52 different cities (84.34%) and unidentified rural areas (15.66%) spread over four regions of the lower 48 states of the U. S., northeast, southeast, central, and west. Table 2 shows the regions and Table 3 exhibits a list of the represented cities.

**Table 2. Percent of Households by Region**

| Region | Percent |
|---|---|
| East | 20.3 |
| West | 20.0 |
| South | 34.3 |
| Central | 25.3 |

The scanner information was collected by date of purchase and included only those panelist that purchased some kind of grocery product in ten out of the twelve-month periods, making a total of 7,195 participating households. The overall data set was divided into four product groupings,

(1) Dry grocery (4,111,719 records),

(2) Dairy (873,899 records),

(3) Frozen (1,002,851 records), and

(4) Random weights (507,306 records),

with each grouping having numerous product modules. Each product module was further subdivided into, brand, size, flavor, form, formula, container, style, type and variety with each one represented each by a unique UPC number.

**Table 3. Locations of Households**

| | City | Percent of Households | | City | Percent of Households |
|---|---|---|---|---|---|
| 1 | Rural | 15.66 | 28 | San Diego | 0.61 |
| 2 | Boston | 1.3 | 29 | St. | 0.96 |
| 3 | Chicago | 10.46 | 30 | Tampa | 0.77 |
| 4 | Houston | 0.56 | 31 | Baltimore | 4.3 |
| 5 | Indianapolis | 1.27 | 32 | Birmingham | 0.25 |
| 6 | Jacksonville | 0.28 | 33 | Buffalo - Rochester | 1.04 |
| 7 | Kansas City | 0.76 | 34 | Hartford- New Haven | 1.17 |
| 8 | Los Angeles | 11.26 | 35 | Little Rock | 0.15 |
| 9 | Suburban New York | 5.47 | 36 | Memphis | 0.08 |
| 10 | Urban New York | 3.81 | 37 | New Orleans - Mobile | 0.18 |
| 11 | Ex-Urban New York | 2.79 | 38 | Oklahoma City - Tulsa | 0.13 |
| 12 | Orlando | 0.48 | 39 | Phoenix | 1.83 |
| 13 | San Francisco | 0.64 | 40 | Raleigh - Durham | 0.23 |
| 14 | Seattle | 0.71 | 41 | Salt Lake City | 1.57 |
| 15 | Atlanta | 13.79 | 42 | Columbus | 0.58 |
| 16 | Cincinnati | 0.94 | 43 | Washington, D. C. | 8.83 |
| 17 | Cleveland | 1.01 | 44 | Albany | 0.49 |
| 18 | Dallas | 0.4 | 45 | Charlotte | 0.56 |
| 19 | Denver | 0.86 | 46 | Des Moines | 0.49 |
| 20 | Detroit | 1.32 | 47 | Grand Rapids | 0.91 |
| 21 | Miami | 0.64 | 48 | Louisville | 0.18 |
| 22 | Milwaukee | 0.63 | 49 | Omaha | 0.56 |
| 23 | Minneapolis | 0.56 | 50 | Richmond | 0.28 |
| 24 | Nashville | 0.16 | 51 | Sacramento | 0.48 |
| 25 | Philadelphia | 1.8 | 52 | San Antonio | 7.51 |
| 26 | Pittsburgh | 1.43 | 53 | Syracuse | 1.45 |
| 27 | Portland, Oregon | 1.09 | | | |

For example, in a sub-group such as dairy a product module is Cheese – Natural – American Cheddar, module number 3550. An overall summary of the number of modules in each product grouping is given in Table 4.

**Table 4. Modules Per Grouping**

| Product Grouping | Number of Modules |
|---|---|
| Dry Grocery | 417 |
| Dairy | 43 |
| Frozen | 43 |
| Random Weights | 119 |

In addition to demographic information total expenditure and quantity information were also recorded for each transaction. This information enabled the imputation of price per unit by transaction, depending on the specified units.

**Data Selection Process**

The data selection process includes all of the steps that are necessary to clean and organize the data in such away so that it was usable for the specified analytical and descriptive purposes of this work.

The first step in the process of obtaining a usable data set was to determine which modules were needed to construct the appropriate data set to be used in the analysis. Of the many hundreds of modules, one module from the dairy group was selected. These raw data were extracted from the original grouping, along with all the appropriate demographic information using SAS.

**Detailed Data Description**

In the original ACNielsen data, there are twenty-one different pieces of information collected for each transaction. Table 5 summarizes the categories of information recorded.

HSD is a panel type data set that is compiled by households overtime and, for ease of access, is grouped by modules. Each module is a general description of the product included in that module. An example of a module is Dairy-Milk – Refrigerated. Products in this module are refrigerated milk in all the different sizes, container types and fat types, etc. Purchases for each household are recorded as they are made.

A household ID number records transactions for each household for the day, month, and year of each individual purchase. A single transaction is comprised of items that are completely homogenous in description and are purchased at the same time by the individual household. The other eighteen categories of information that are recorded in the original data set relate to quantity, cost, or product description for each purchase.

The quantity description includes the size of the unit purchase, which is measured in thousandths of ounces. The word "multi" refers to the number of units per package, and the quantity to the number of bundles or packages.

**Table 5. Information Collected in the Home Scanner Data Set**

| # | Type of Information Collected |
|---|---|
| 1 | Household Id |
| 2 | Purchase Date ( YYMMDD) |
| 3 | Product Module |
| 4 | Brand |
| 5 | Size |
| 6 | Multi |
| 7 | UPC (Universal Price Code) |
| 8 | UPC Description |
| 9 | Quantity (Packages) |
| 10 | Price Paid Deal |
| 11 | Price Paid Non-Deal |
| 12 | Coupon Value |
| 13 | Flavor |
| 14 | Form |
| 15 | Formula |
| 16 | Container (Type) |
| 17 | Salt Content |
| 18 | Style |
| 19 | Type |
| 20 | Product |
| 21 | Variety |

Cost information comes in three forms. Each of the three forms is in reference to total expenditure or total value per transaction. Price Paid Non-Deal (PPND) refers to a purchase where no coupon or promotional discount is recognized. Price Paid Deal (PPD) is the total expenditure of the transaction recognizing there is a discount, however, the recorded price is not adjusted for the value of the coupon or discount. The PPND has no adjustment for promotion or coupon value and is the actual expenditure for that transaction, while the PPD must have the coupon value subtracted from it before it is the actual transaction expenditure.

Of the remaining twelve descriptive categories, seven contain no information for milk. These categories are flavor, form, formula, salt content, style, variety, and product. The two UPC categories contain the UPC number code for each product and a UPC abbreviated description. The remaining three descriptions are for brand, container type, and content type. The brand describes a product seller or manufacturer and can be either a name brand such as Adhor Farms or a private label brand, such as Albertson's or some other store brand. The container type has four possibilities, plastic, glass, pouch, and carton. Type is an abbreviated description of the label declaration of fat content.

**Hedonic Data Set Creation**

Extraction of the data from the original or full data set requires a program that is capable of handling large amounts of information, since the number of total transactions is in the millions. SAS is such a program and is used for the compilation of the data set used for hedonic price analysis. A description follows of each of the variable categories and how they were extracted and modified to form the data set to be used by the econometric package used to build the hedonic price models.

Only the month number portion of the date variable was included in the new data set, resulting in assigning the months consecutive numbers starting with one for January and ending with twelve for December.

Brands are designation as one of two types. Private label brands were given the value of 1, and all other name brands are designated as 0. This new indicator variable is known as label. White milk had a total of three hundred eighty-three brand types consisting of one aggregated private label brand and three hundred eighty-two name brands.

The variable for container type is simply named "cont.", an abbreviation for container.

The size variable in the original data is converted to ounces and named "ounces". This is accomplished by dividing the original size variable by one thousand.

Only the three most common sizes of milk purchases, the gallon, half-gallon, and quart are included. It is likely that supermarket purchases of milk will occur in these sizes, whereas other sizes are more likely to be bought in other venues. Aside from these three sizes other odd sizes are observed that range in size from 24 ounces to 127.8 ounces. However, the odd sized containers only occur two hundred nine times out of over two hundred fifty-two thousand occurrences. They account for about .08 percent of all observations. Rather than exclude these uncommon container sizes, they are classified to the closest common size. The sizes are coded into a variable known as "jug" with a representation of 1 for the gallon size, 2 for half-gallon, and 3 for quart. A full description of the containers by size, and assignment of odd container sizes are shown in Table 6.

**Table 6. Transactions by Container**

| Ounces | Container Size | Coding | Number of Codings |
|---|---|---|---|
| 128 | gallon | 1 | 148,590 |
| 127.8 | gallon | 1 | 16 |
| 114 | gallon | 1 | 20 |
| 101.4 | gallon | 1 | 77 |
| **Total** | | | **148,703** |
| 88 | half-gallon | 2 | 63 |
| 72 | half-gallon | 2 | 13 |
| 64 | half-gallon | 2 | 80,847 |
| 57 | half-gallon | 2 | 5 |
| **Total** | | | **80,928** |
| 32 | quart | 3 | 26,468 |
| 24 | quart | 3 | 15 |
| **Total** | | | **26,483** |
| | All Transactions | | 256,114 |
| | Odd-sized Container | | 209 |

The total expenditure per transaction was transformed into a variable identified as "price", which is derived from the PPND, PPD and the coupon value. The total expenditure for a single transaction is equal to either the PPND or PPD minus the value of the coupon. Remember that a coupon value is only present if there was a deal offered. The actual value or expenditure is then divided by the number of containers purchased per transaction, either as a, quart, half-gallon, or gallon, which gives an imputed price per container, identified as the variable "untprice".

There are 102 different fat types in the original data set. The original data set contains a brief description of each type of milk sold at the various stores across the U.S.. This abbreviation includes an indication of fat type. All 102 different descriptions are evaluated by physical observation and are assigned according to one of five classifications and coded as 0, 1, 2, 3, or 4 under the new variable known as "fat". The assignment of the five numbers are as follows, whole milk (approx. 3% or more fat) coded as a 1, reduced fat milk (approx 2% fat) coded as 2, low-fat milk (approx. 1% fat) coded as 3, skim milk (approx. 0% fat) coded as 4, and unclassifiable descriptions as 0.

In addition to the nine products description variables, just discussed, eighteen demographic or household description variables were transferred from the original data set to the hedonic price data set, to be used as control variables in the hedonic estimation.

**Description of the Hedonic Data Set**

The study of hedonic prices for all fluid white milk required the extraction of each individual transaction from the Dairy-Refrigerated-Milk module (3625), which has a total of 247,913 transactions, but only 243,913 transactions were available for use. The remaining 3202 observations were either excluded for container sizes smaller then a quart, or were unclassifiable for fat types. A summary of the number of dropped transactions and the reason they were excluded is exhibited in Table 7.

**Table 7. Dropped Observations**

| Number of Observations Dropped | Reason Observations was Dropped |
|---|---|
| 513 | Unclassifiable fat types. |
| 2663 | Smaller then the quart size. |
| 26 | Both unclassifiable fat and smaller than quart size. |
| 3202 | Total number dropped from the sample. |

Module 3625 contains only white milk and is in the Dairy Products group along with forty other dairy product modules. A complete statistical breakdown of average cost by container size and fat type for this module can be seen in Table 8. The highest price paid for a gallon of milk is $9.22 for whole milk while the highest half-gallon price is $4.39 for skim milk. The highest price for a quart of milk is $3.39 for skim milk. The minimum price for all types and container sizes of milk is zero, which indicates that each type and size was acquired during the year by at least one household for a zero price. This situation is most likely the result of special deals or promotions. An example of such a deal or promotion would be the purchase of two units with a third unit given at no charge.

**Table 8. Statistical Description of Milk by Fat Type and Container Size**

| Container Size | Number of Transactions | Mean Price in Dollars | Standard Deviation | Minimum Observation in Dollars | Maximum Observation in Dollars |
|---|---|---|---|---|---|
| | | White Milk | | | |
| Gallon | 147,464 | $2.51 | $0.50 | $0.00 | $9.22 |
| Half-Gallon | 75,357 | $1.68 | $0.46 | $0.00 | $4.39 |
| Quarts | 21,092 | $1.11 | $0.34 | $0.00 | $3.39 |
| *Total* | 243,913 | | | | |
| | | Whole Milk | | | |
| Gallon | 28,299 | $2.66 | $0.49 | $0.00 | $9.22 |
| Half-Gallon | 14,289 | $1.67 | $0.34 | $0.00 | $3.99 |
| Quarts | 5,418 | $1.07 | $0.29 | $0.00 | $1.99 |
| *Total* | 48,006 | | | | |
| | | Reduced Fat Milk | | | |
| Gallon | 55,502 | $2.49 | $0.50 | $0.00 | $7.47 |
| Half-Gallon | 23,268 | $1.64 | $0.43 | $0.00 | $3.99 |
| Quarts | 5,958 | $1.09 | $0.33 | $0.00 | $3.00 |
| *Total* | 84,728 | | | | |
| | | Low-fat Milk | | | |
| Gallon | 25,782 | $2.51 | $0.50 | $0.00 | $5.69 |
| Half-Gallon | 13,864 | $1.68 | $0.46 | $0.00 | $3.99 |
| Quarts | 2,427 | $1.13 | $0.36 | $0.00 | $2.49 |
| *Total* | 42,073 | | | | |
| | | Skim Milk | | | |
| Gallon | 37,881 | $2.42 | $0.50 | $0.00 | $8.18 |
| Half-Gallon | 23,936 | $1.73 | $0.53 | $0.00 | $4.39 |
| Quarts | 7,289 | $1.14 | $0.38 | $0.00 | $3.39 |
| *Total* | 69,106 | | | | |

A description of the percentage of transactions by container size and fat type can be found in Table 9. The reduced fat milk category has the largest number of transactions with thirty-five percent, followed by skim milk with twenty-eight percent of all transactions, then whole milk with twenty percent, and, with the least number of transactions, low-fat milk at seventeen percent.

The average number of transaction per household annually for all white milk is about thirty-four purchases. Twenty and one-half of those purchases are for gallon-sized containers; ten and one-half are half-gallon size purchases with the remaining three purchases being for the quart size. Statistics for the other fat types are available in Table 9. Table 10 shows monthly transaction activity by container type.

Table 11 summarizes information about container type with respect to size. Plastic containers are most common for the gallon size making up 99 percent of all gallons sold, half-gallons are closely split between plastic and other types with 46 percent of the transactions being in plastic the remaining 54 percent in other than plastic containers. The quart size container has the most transactions for containers other than plastic, with 85 percent and the remaining fifteen percent of transactions being made in plastic containers.

**Table 9. Transaction Activity by Fat Type and Container Size**

| Container Size | Number of Transactions | Percent of Transactions by Category Sales | Percent of Transactions of All Milk Sales | Average Number of Transactions Annually Per Household |
|---|---|---|---|---|
| | | All White Milk | | |
| Gallon | 147,464 | - | 60% | 20.5 |
| Half-Gallon | 75,357 | - | 31% | 10.5 |
| Quart | 21,092 | - | 9% | 2.9 |
| *Total* | 222,821 | - | 100% | |
| | | Whole Milk | | |
| Gallon | 28,299 | 59% | 12% | 3.9 |
| Half-Gallon | 14,289 | 30% | 6% | 2 |
| Quart | 5,418 | 11% | 2% | 0.8 |
| *Total* | 42,588 | | 20% | |
| | | Reduced Fat Milk | | |
| Gallon | 55,502 | 66% | 23% | 7.7 |
| Half-Gallon | 23,268 | 27% | 10% | 3.2 |
| Quart | 5,958 | 7% | 2% | 0.8 |
| *Total* | 78,770 | | 35% | |
| | | Low-fat Milk | | |
| Gallon | 25,782 | 55% | 16% | 3.6 |
| Half-Gallon | 13,864 | 35% | 10% | 1.9 |
| Quart | 2,427 | 11% | 3% | 1.0 |
| *Total* | 39,646 | | 28% | |
| | | Skim Milk | | |
| Gallon | 37,881 | 55% | 16% | 5.3 |
| Half-Gallon | 23,936 | 35% | 10% | 3.3 |
| Quart | 7,289 | 11% | 3% | 1.0 |
| *Total* | 61,817 | | 28% | |

**Table 10. Percent of Transactions by Month**

| Month | Gallons | Half-Gallons | Quarts |
|---|---|---|---|
| January | 8.74% | 8.77% | 8.43% |
| February | 8.13% | 8.29% | 7.97% |
| March | 8.98% | 8.65% | 8.79% |
| April | 8.47% | 8.45% | 8.21% |
| May | 8.71% | 8.54% | 8.61% |
| June | 8.10% | 8.26% | 8.33% |
| July | 8.37% | 8.41% | 8.54% |
| August | 8.37% | 8.47% | 8.44% |
| September | 8.05% | 8.08% | 8.38% |
| October | 8.25% | 8.46% | 8.59% |
| November | 7.69% | 7.91% | 7.70% |
| December | 8.14% | 7.71% | 8.01% |
| | 100.00% | 100.00% | 100.00% |

**Table 11. Container Type Information by Container Size**

| | Container Size | | |
|---|---|---|---|
| Container Type | Gallons | Half-Gallons | Quarts |
| Plastic | 99% | 46% | 15% |
| Non-plastic | 1% | 54% | 85% |

The number of transaction fluctuates from month to month. Figure 1 gives a clear visualization of these monthly fluctuations.

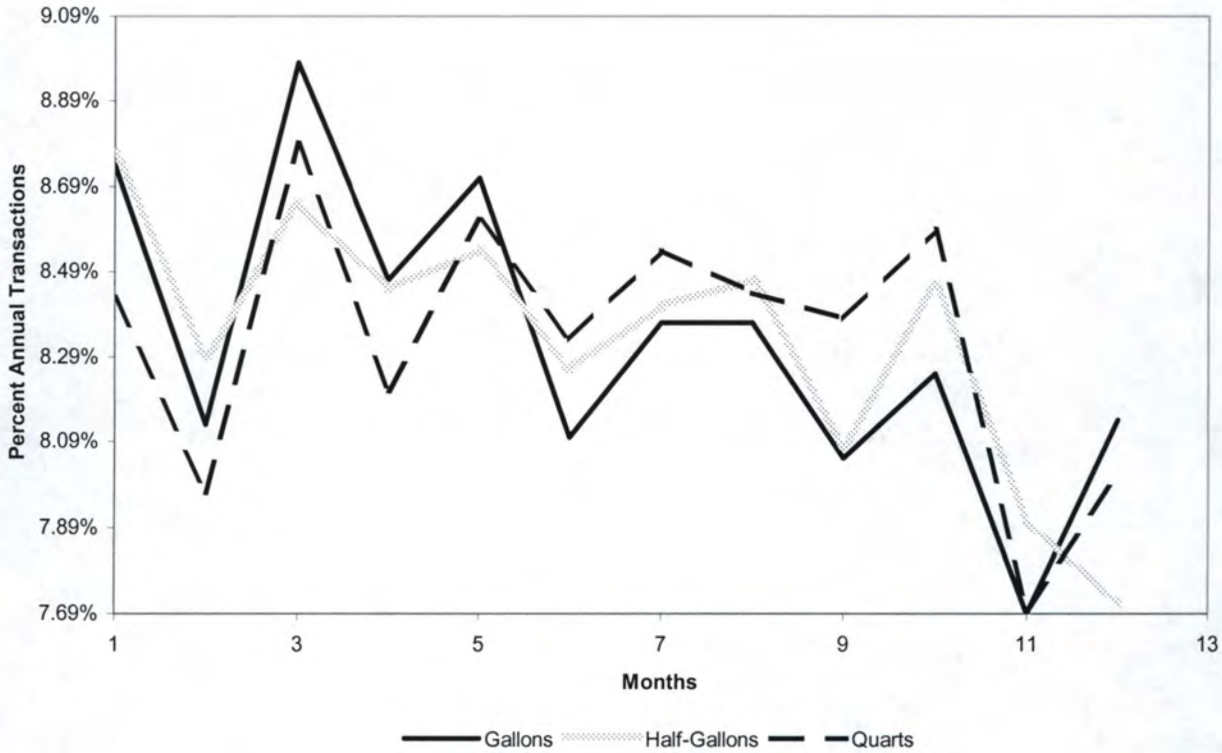


**Figure 1. A Graph of percent of annual transactions by month**

However transaction activity only ranges between a high of 8.9 percent to a low of 7.69 percent.

Table 12 shows the percentages of transactions made by brand type. Name brand products account for 34 percent of all the gallon transactions, 45 percent of the half-gallon size transactions, and for 54 percent of the quart size transactions. This indicates that as the size of the container increases the percentage of private label transactions also increases.

**Table 12. Brand Classification by Container Size**

| | Brand Classification | | |
|---|---|---|---|
| Brand Type | Gallons | Half-Gallons | Quarts |
| Branded | 34% | 45% | 54% |
| Private Label | 66% | 55% | 46% |

## Methodology

Critical to the implementation of the Nerlovian hedonic methodology is the keystone that prices be exogenous. The basis for assuming exogenous prices for retail fluid milk is logical. The commodities in the ACNielsen home scan (HSD) data set are items sold in retail stores recorded at the time of purchase by households at home. The data set is representative of individual consumers/households buying as much as they wish of any one of the commodities at the listed or posted price offered by any particular store. If one accepts that this condition holds, then prices may be considered exogenous. If prices are exogenous, which implies that the supply curve is perfectly elastic, consumers can buy all they wish of any item at its posted price. Nerlove labels this case as polar case two. Nerlove has shown that, in this case, the appropriate econometric estimation methodology is with the dependent variable as quantities ( NHPE methodology) in lieu of prices.

Nerlove's main point for offering an alternative to the standard or Waughian hedonic price estimation (WHPE) methodology is based on the recognition that prices may be exogenous. In only two special cases of market structure can the direct estimation of hedonic prices when made result in estimates that are free from identification issues.

These two methods are polar opposites with regard to the assumptions about market conditions, which justify their appropriate application. The market structure conditions are carried over into the construction of the particular econometric models, which further lead to different specifications and use of variables in the actual estimation. Since the specifications and estimation variables are different, it is expected that the estimates themselves would be quite different. Given these facts and to illustrate the importance of properly applying the correct hedonic price model, both hedonic methodologies, NHPE and WHPE, are implemented using a linear functional form.

To reiterate Nerlove's point about the difference in the two models, the comparison between the estimates is a statement about the difference in outcome when there are differences in the price discovery process. What this means is that the resulting estimates are really not comparable. Rather, a comparison of results is an illustration of how different the estimates would be given different market structures. It must also be remembered that the NHPE and WHPE are only valid given the two extremes in the price discovery process, and that any other market structure involves identification issues that must be addressed using some other type of model.

The three NHPE models are estimated using quantity as the dependent variable. As Nerlove states, "we should regress the quantities consumed on the unit variety price and the measures of quality attributes which characterize that variety, Q(Z) = R[P(Z), a(Z), Y].". Noting that P, price, is a function of Z attributes, a(Z) represents consumers' valuation of various quality characteristics, and Y is a vector of income and other consumer characteristics. The standard or WHPE model is less complex and, using Nerlove's notation, would be written as P(Z) = G[a(Z), Y].

Nerlove uses a double log specification, but other types of specifications could be used. For the purposes of this paper and to maintain manageability, only the linear functional form is used. There are three unit sizes, gallon, half-gallon, and quart. A total of six models are constructed and compared, three models of the NHPE and three WHPE. The three models of each type were done by container size. Hedonic price models are used to separate out the price effects of different attributes or characteristics of a particular good in this case the Z's, a vector of attributes. The variables $a(Z_i)$ are interpreted as the consumer's valuation of the $i^{th}$ attributes of fat types, container types, and brands. Y denotes the inclusion of variables into the model to account for demographic differences and seasonality. An indicator variable for each of the months but one was included, with the exception of December, the base month. The hedonic process is repeated for each of the three different container sizes of milk.

It should be noted that white milk is categorized into four fat levels of whole fat (WM), reduced fat (RM), low fat (LM), and nonfat (NM) levels. There are four different container types, cardboard, glass, plastic, and pouch. However, very few observations are available for the pouch and glass container types, making it logical to combine all other non-plastic containers as one group. Combining container types reduces the number of categories to two, plastic or non-plastic. Brand type is either classified as private label, in house brand, or as proprietary or name brand. An inclusion of all the many brands would make the estimation quite unwieldy given that there are a large number of brands. The brand simplification is efficient but still provides a useful division that manufacturers' or name brand owners, and store chains, private label owners would find useful. Milk generally is associated with seasonal consumption and is therefore modeled with monthly indicator variables. The mathematical representation of the two models is presented in Figure 2, the NHPE equation and model, and Figure 3, the WHPE equation and model.

To justify the inclusion of the demographic variables in each of the six models, the eleven groups of demographic and seasonal adjustment variables were tested using F-tests. The null hypothesis for these F-test, by groups is that the effects of the specific group of demographic variables or seasonal variables are jointly equal to zero. Each of the models has a different demographic or seasonal variables that is found not to be significantly different from zero, except in the NHPE model for half-gallons which has no group or seasonal variables where the null hypothesis is not rejected.

$$(4\text{-}1) \quad Q_{tp} = \beta_{p0} + \rho_p V_{tp} + \sum_{i=1}^{22} \gamma_{pi} X_{tpi} + \sum_{j=1}^{11} \beta_{pj} Y_{tpj} + \sum_{k=1}^{5} \alpha_{pk} Z_{tpk} + \eta_{tp}$$

Equation 4-1 The Nerlovian Hedonic Price Equation (NHPE) model

$Q_{tp}$ - is the quantity for the $t^{th}$ transaction and the $p^{th}$ container size. Where $p$ = gallons, half-gallons, or quarts, and $t$ = the number of transactions.
$\beta_{p0}$ – the base effect of the $p^{th}$ container size, where p = gallons, half-gallons, or quarts.
$\rho_P$ - estimated effect of the $p^{th}$ container size. Where $p$=gallons, half-gallons, or quarts.
$V_{tp}$ – the price of the $p^{th}$ container size for the $t^{th}$ transactions.
$\gamma_{pi}$ - is the parameters estimate for the effect for $p^{th}$ container size and the $i^{th}$ demographic indicator variable, where $p$ = gallons, half-gallons, or quarts, and $i$ = 1 to 22 demographic variables.
$X_{tij}$ - the presence of the $i^{th}$ demographic, for the $p^{th}$ container size and $t^{th}$ transaction. Where $j$ = 1 to 11, $p$ = gallons, half-gallons, or quarts, and $t$ = number of transactions.
$\beta_{pj}$ - beta is the parameter estimate for the $p^{th}$ container size and the $j^{th}$ month. Where $p$ = gallons, half-gallons, or quarts, and $j$ = 1 to 11 months.
$Y_{tpj}$ - the presence of the $j^{th}$ month, for the $p^{th}$ container size and $t^{th}$ transaction. Where $j$ = 1 to 11, $p$ = gallons, half-gallons, or quarts, and $t$ = number of transactions.
$\alpha_{pk}$ - alpha is the parameter estimate of the marginal effects of the $k^{th}$ attribute for the $p^{th}$ container size. Where $k$ = 5 attributes, and $p$ = gallons, half-gallons, or quarts.
$Z_{tpj}$ - the presence of the $k^{th}$ attribute, for the $p^{th}$ container size and $t^{th}$ transaction. Where $k$ = 1 to 5, $p$ = gallons, half-gallons, or quarts, and $t$ = number of transactions.
$\eta_{pt}$ - the unexplained residual for the $p^{th}$ container size and the $t^{th}$ transaction. Where $p$ = gallons, half-gallons, or quarts and $t$ = number of transactions.

**Figure 2. The NHPE equation and model**

(4-2) $$P_{tp}" = \beta_{p0}" + \sum_{i=1}^{22} \gamma_{pi}" X_{tpi} + \sum_{j=1}^{11} \beta_{pj}" Y_{tpj} + \sum_{k=1}^{5} \alpha_{pk}" Z_{tpk} + \omega_{tp}$$

Equation 4-2 The Waughian Hedonic Price Equation (WHPE) model

$P_{tp}"$ - is the unit price for the $t^{th}$ transaction and the $p^{th}$ container size. Where p = gallons, half-gallons, or quarts, and t = the number of transactions for the WHPE model.

$\beta_{p0}"$ - the base effect of the $p^{th}$ container size, where p = gallons, half-gallons, or quarts.

$\gamma_{pi}"$ - is the parameters estimate for the effect for $p^{th}$ container size and the $i^{th}$ demographic indicator variable, where p = gallons, half-gallons, or quarts, and i = 1 to 22 demographic variables.

$\beta_{pj}"$ - beta is the parameter estimate for the $p^{th}$ container size and the $j^{th}$ month. Where p = gallons, half-gallons, or quarts, and j = 1 to 11 months.

$Y_{tpj}$ - the presence of the $j^{th}$ month, for the $p^{th}$ container size and $t^{th}$ transaction. Where j = 1 to 11, p = gallons, half-gallons, or quarts, and t = number of transactions.

$\alpha_{pk}"$ - alpha is the parameter estimate of the marginal effects of the kth attribute for the pth container size. Where k = 5 attributes, and p = gallons, half-gallons, or quarts.

$Z_{tpj}$ – the presence of the $k^{th}$ attribute, for the $p^{th}$ container size and $t^{th}$ transaction. Where k = 1 to 5, p = gallons, half-gallons, or quarts, and t = number of transactions.

$\omega_{pt}$ - the unexplained residual for the $p^{th}$ container size and the $t^{th}$ transaction. Where p = gallons, half-gallons, or quarts and t = number of transactions.

**Figure 3. The WHPE equation and model**

The gallon size models for the WHPE and NHPE each have one demographic group dropped. The WHPE dropped the demographic group “no children present”, and the NHPE dropped the ethnic origin group of Hispanic. Table 13 shows the gallon size WHPE and NHPE models F-test summaries.

The half-gallon size group F-test found in Table 14 indicates that the WHPE model has four groups dropped: (1) employment of the female head of house, (2) education of the female head of house, (3) ethnic origin of Hispanic, and (4) household sizes. As previously mentioned the half-gallon NHPE model had no demographic or seasonal variables dropped.

**Table 13. Demographic Group F-test for Gallon Size**

| | Waughian Model | | Nerlovian Model | |
|---|---|---|---|---|
| Demographic Group | F Statistic | p-values | F Statistic | p-values |
| Age of FHH* | 124.91 | 0.000 | 25.73 | 0.000 |
| Employment Status FHH* | 10.69 | 0.000 | 58.05 | 0.000 |
| Education of the FHH* | 46.18 | 0.000 | 14.54 | 0.000 |
| Race | 4.01 | 0.018 | 74.33 | 0.000 |
| Hispanic | 9.69 | 0.002 | **0.97** | **0.324** |
| Non City Dwelling | 64.89 | 0.000 | 13.36 | 0.000 |
| Region | 896.16 | 0.000 | 1285.76 | 0.000 |
| Martial Status | 50.47 | 0.000 | 17.63 | 0.000 |
| No Children Present | **0.03** | **0.869** | 17.11 | 0.000 |
| Household Size | 24.38 | 0.000 | 459.77 | 0.000 |
| Seasonal Effect, Months | 858.35 | 0.000 | 7.67 | 0.000 |

- FHH, Female Head of Household

The **bolded** values are the variables dropped from the models.

**Table 14. Demographic Group F-test for Half-Gallon Size**

| | Waughian Model | | Nerlovian Model | |
|---|---|---|---|---|
| Demographic Group | F Statistic | p-values | F Statistic | p-values |
| Age of FHH* | 7.79 | 0.00 | 33.70 | 0.00 |
| Employment Status FHH* | **2.68** | **0.07** | 9.26 | 0.00 |
| Education of the FHH* | **1.62** | **0.20** | 20.12 | 0.00 |
| Race | 249.60 | 0.00 | 17.62 | 0.00 |
| Hispanic | **1.75** | **0.19** | 32.57 | 0.00 |
| Non City Dwelling | 465.82 | 0.00 | 75.29 | 0.00 |
| Region | 1603.78 | 0.00 | 155.44 | 0.00 |
| Martial Status | 31.21 | 0.00 | 26.41 | 0.00 |
| No Children Present | 24.73 | 0.00 | 19.24 | 0.00 |
| Household Size | **1.19** | **0.31** | 360.39 | 0.00 |
| Seasonal Effect, Months | 120.44 | 0.00 | 6.09 | 0.00 |

*FHH, Female Head of Household

The F-test for the Quart-size model results in five groups of demographic and seasonal variables being removed from the two models, three from the WHPE model and two from the NHPE model. The three groups removed from the WHPE are (1) employment of the female head, (2) ethnicity of Hispanic, and (3) no kids present in the household. The two groups removed from the NHPE model are (1) Hispanic ethnicity, and (2) the seasonal variables group. Table 15 shows a summary of the demographic groups and seasonal variables F-test results.

**Table 15. Demographic Group F-test for Quart Size**

| | Waughian Model | | Nerlovian Model | |
|---|---|---|---|---|
| Demographic Group | F Statistic | p-values | F Statistic | p-values |
| Age of FHH | 17.00 | 0.000 | 10.54 | 0.000 |
| Employment Status FHH | **0.31** | **0.736** | 28.71 | 0.000 |
| Education of the FHH | 14.37 | 0.000 | 37.54 | 0.000 |
| Race | 59.43 | 0.000 | 4.22 | 0.015 |
| Hispanic | **1.20** | **0.273** | **0.17** | **0.679** |
| Non City Dwelling | 366.48 | 0.000 | 12.74 | 0.000 |
| Region | 919.61 | 0.000 | 8.29 | 0.000 |
| Martial Status | 9.56 | 0.000 | 7.77 | 0.000 |
| No Children Present | **3.31** | **0.069** | 11.03 | 0.001 |
| Household Size | 27.80 | 0.000 | 24.16 | 0.000 |
| Seasonal Effect, Months | 15.89 | 0.000 | **0.96** | **0.485** |

* FHH, Female Head of Household

After the removal of the demographic and seasonal variable groups the models are estimated. In the case of the NHPE model it is necessary to use the coefficient estimates to impute the price for the NHPE model. The hedonic price for the NPHE model does not have the same interpretation as standard or WHPE model. The NHPE hedonic price is defined as the consumer's willingness to pay, given the ceteris paribus condition that quantities are held constant. The WHPE model hedonic price is interpreted as the marginal effects of the attributes on price.

The marginal implicit value for an attribute in the WHPE is simply the derivative $dP/dZ_i$. Setting the total derivative of the NHPE function equal zero and solving for the dP/dZi derives the NHPE hedonic price, or willingness to pay. When calculating the hedonic price for either of these models it is assumed that there are no changes in any of the demographics or that the change in the demographic variables is zero so the Y's drop out of both equations. Figure 4 shows the general mathematical manipulations used to derive the partial $dP/dZ_i$ for the NHPE model.

$dQ = (\partial R/\partial P)\, dP + (\partial R/\partial Zi) dZi$

Where $dQ = 0$

Solve to get

$dP/dZ_i = - (\partial R/\partial Z_i/\partial R/\partial P)$.

**Figure 4. The mathematical derivation of the Nerlovian hedonic price equation**

Therefore, by holding quantity constant and allowing attributes to change, for example, changing price and attribute mix, a change in price with respect to a change in attributes results. Remember that although the derivatives look the same, the estimated models are based on different sets of assumptions and therefore are not comparable.

To help clarify the Nerlovian hedonic price a graphical example is given. See Figure 5. Let $P_1$ be the original price of the demand function $R_1(p,z)$, assume that the change in quantity is zero, thus quantity is fixed at Q*. Then a change in characteristic z, z being a good attribute and assuming the change in z is positive, a more desirable characteristic mix results in an outward demand shift, $R_2(p,z)$. In order to keep quantity fixed at Q* with this demand shift requires that the price must rise to $P_2$. This simple graph illustrates this condition and helps clarify why the Nerlovian hedonic price it is not comparable to the Waughian hedonic price.

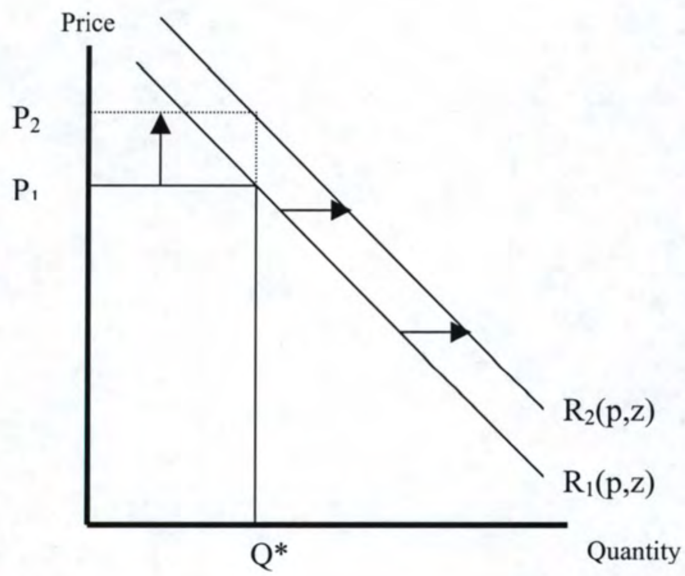


**Figure 5. *Ceteris Paribus* conditions of the Nerlovian hedonic price model**

Operationally, the NHPE is derived as the negative of the coefficient of the attribute $\alpha_{pk}$, divided by the coefficient of the price variable $\rho_{P}$, both from the NHPE model. This procedure is repeated for each $k^{th}$ attribute. The delta method is used to test the NHPE hedonic prices, since each estimate is a combination of primal estimated parameters. This testing procedure is done using the Shazam test statements. The hedonic prices for the WHPE model are simply the coefficients $\alpha_{pk}''$, for a specific container size *p,* and $k^{th}$ attribute and requires no other special testing procedure to test statistical significance, other than the student t test. To show how different the NHPE's are from the WHPE's they are both put into the same table. A separate table was constructed for each of the three container sizes.

**Results**

The complete list of coefficient estimates and their respective standard errors, t-statistics, and p-values are in Appendix A. Also in Appendix A is a measure for goodness-of-fit, and R-square, for each model.

Before going further into the detailed results it is helpful to re-emphasize the difference between the interpretations of the two models' hedonic price estimates. The NPHE estimates are interpreted as the consumers' willingness to pay based on transactional quantities. Therefore, the final estimates are reflective of the average consumer's willingness to pay for specific attributes while holding quantities constant. The WHPE model is the average marginal implicit valuation of the characteristic. The

WHPE uses the per unit price per transaction as the dependent variable, whereas the NHPE uses a per transaction quantity as the dependent variable.

The NHPE model for the gallon size has all positive coefficients except for whole milk. Since private label reduced fat milk in the plastic container is the base, and variation from base is what the estimates measure, branded milk, skim milk, low-fat milk, and non-plastic containers are positively valued while whole milk has a negative value. The negative value is representative of a willingness to accept a discount. All of the estimates are statistically significant for both the NHPE and WHPE models as shown in Table 16. The magnitude of the hedonic price estimate for non-plastic container type, is quite large, nearly 380 cents. This inflated value is more than the average price per gallon. This large value may stem from several sources. One cause may be the fact that such a small number of the containers in the gallon size are non-plastic, less than 1%. Although the number of observations associated with the container type attribute is small, the effects are consistently large, making the estimate of the coefficient for container type large relative to the price coefficient and resulting in the current hedonic price imputation for container type.

The consumers' willingness to pay for branded gallons of milk was 21.95 cents. Consumers who bought branded milk were willing to pay 21.95 cents more than for unbranded gallons of milk. The WHPE model estimated the average marginal valuation of branded milk as 6.54 cents, representing the average transactions valuation over all consumers greater than the base price.

The WHPE hedonic price estimate for non-plastic containers was 17.51 cent less than the base container type, plastic, while the NHPE price was 379.13 cents higher than the base. As mentioned, the cheaper price of non-plastic containers and the increased quantity per transaction, with the assumption of fixed quantities results in this large NHPE estimate.

The marginal implicit price for skim milk derived from the WHPE model was -6.71 and the NHPE willingness to pay of those who consumed skim milk was 16.43 cents higher then that for two percent milk. When quantities are unchanged those that consume skim milk are willing to pay 16.43 cents more than for reduced fat milk.

**Table 16. Hedonic Models – Gallon-Size Containers**

| **Attribute , $Z_i$** | **NHPE, ($dR/dZ_i$)** | **-($dR/dZ_i$)/($dR/dP$)** | **WHPE, ($dG/dZ_i$)** |
|---|---|---|---|
| Brand vs. Private Label | 0.0227 | 21.95 | 6.54 |
| *p-values* | 0.00 | 0.00 | 0.00 |
| Non-Plastic Container | 0.3920 | 379.13 | -17.51 |
| *p-values* | 0.00 | 0.00 | 0.00 |
| White Skim milk | 0.0170 | 16.43 | -6.71 |
| *p-values* | 0.00 | 0.00 | 0.00 |
| White Lowfat milk | 0.0297 | 28.75 | 0.834 |
| *p-values* | 0.00 | 0.00 | 0.02 |
| White Whole milk | -0.0253 | -24.50 | 14.94 |
| *p-values* | 0.00 | 0.00 | 0.00 |
| (dR/dP) from the NHPE = | | -0.0010 | |
| *p-value* | | 0.00 | |

See Figures 2,3 and 4 for definitions and explanation of the headings and acronyms.

Low-fat milk has an average marginal attribute value of less then one cent over two percent fat milk, but the willingness to pay is 28.75 cents more then for two percent fat milk. The willingness to pay stems fro the larger sizes of the transaction quantities of low-fat milk relative to reduced fat milk.

Whole milk in the gallon size has an average marginal attribute value of 14.53 cents more than that of reduced fat milk. The willingness to pay for unchanged quantities low-fat milk is 24.50 cents less than reduced fat milk. Whole milk as an attribute decreases quantity per transaction relative to reduced fat milk as seen from the coefficients of the NHPE model. Therefore, the constant quantity assumption, in the presence of a negative sloping demand function causes the willingness-to-pay of consumers to also be negative.

From Table 17, which shows the half-gallon size container results, all five of the attribute coefficients for the WHPE model are positive. The NHPE model has positive coefficient estimates for two attributes, brand and non-plastic containers while the remaining three coefficients for the three fat types, skim milk, low-fat milk, and whole milk are negative. Fat types have a negative impact on price relative to reduced fat milk. In the WHPE model all fat types have a positive effect making the average price paid for fat types being higher than the base showing a positive effect on price.

Consumers who bought branded milk are willing to pay 40.68 cents more then for unbranded half-gallons of milk, quantities remaining constant. The WHPE model estimates the average marginal valuation of branded half-gallons at 20.70 cents, making branded half-gallons that much more costly than private label half-gallons on average.

**Table 17. Hedonic Models – Half-Gallon-size Containers**

| Attribute , $Z_i$ | NHPE, $(dR/dZ_i)$ | $-(dR/dZ_i)/(dR/dP)$ | WHPE, $(dG/dZ_i)$ |
|---|---|---|---|
| Brand vs. Private Label | 0.0528 | 40.68 | 20.70 |
| *p-values* | 0.0000 | 0.00 | 0.00 |
| Non-Plastic Container | 0.0785 | 60.46 | 9.47 |
| *p-values* | 0.0000 | 0.00 | 0.00 |
| White Skim milk | -0.0163 | -12.58 | 8.39 |
| *p-values* | 0.0030 | 0.00 | 0.00 |
| White Lowfat milk | -0.0120 | -9.28 | 4.78 |
| *p-values* | 0.0590 | 0.06 | 0.00 |
| White Whole milk | -0.0667 | -51.41 | 3.82 |
| *p-values* | 0.0000 | 0.0000 | 0.0000 |
| (dR/dP) from the NHPE = | | -0.00130 | |
| *p-value* | | 0.000 | |

See Figures 2,3 and 4 for definitions and explanation of the headings and acronyms.

The WHPE non-plastic container type hedonic price estimate is 9.47 cents more than the base container type, plastic. The NHPE price is 60.46 cents higher than the base, which is consistent with the higher price of non-plastic containers and the increased quantity per transaction.

The skim milk hedonic price for the WHPE model is a positive 8.39 cents and the NHPE willingness to pay for those who consumed skim milk is -12.58 cents both relative to reduced fat milk. On average, skim milk implicit price is 8.39 cents more than reduced fat milk. To maintain unchanged quantities, those that consume skim milk would value it at being worth 12.58 cents less than reduced fat milk. This valuation is supported by the negative impact that skim milk has on the magnitude of the transaction quantity.

Low-fat milk has a marginal attribute value of 4.78 cents, but the willingness to pay is - 9.28 cents, both relative to reduced fat milk. Again, the negative outcome is the result of the negative effect that low-fat milk has on the transaction quantity relative to reduced fat milk.

Whole milk in the half-gallon size costs an average of 3.82 cents more than reduced fat milk, while the willingness to pay for unchanged quantities by consumers is 51.41 cents less than reduced fat milk. Whole milk, as an attribute, decreases quantity per transaction relative to reduced fat milk, and therefore given the constant quantity assumption, requires the willingness to pay of consumers to be a discount value or negative amount relative to the base.

The results for the final container size need special consideration because they have a unique outcome. The relationship between price and quantity is positive unlike the expected outcome when estimating a typical demand function. As seen in Table 18, the change in quantity with respect to price (dR/dP) is positive. This unexpected result affects the interpretation of the change in price with respect to the $i^{th}$ attribute ($dP/dZ_i$) for the NHPE model. The mathematical relationship used to derive $dP/dZ_i$ is determined by the negative of the ratio of the change in quantity with respect of the $i^{th}$ attribute ($dR/dZ_i$) and dR/dP, which when dR/dP is positive, makes the NHPE hedonic price of opposite sign of the $dR/dZ_i$. Whatever attribute has a positive effect on quantity, will have the opposite effect on the hedonic price, and if the attribute effect is negative on quantity it has a positive effect on hedonic price.

**Table 18. Hedonic Models – Quart -Size Containers**

| Attribute , $Z_i$ | NHPE, $(dR/dZ_i)$ | $-(dR/dZ_i)/(dR/dP)$ | WHPE, $(dG/dZ_i)$ |
|---|---|---|---|
| Brand vs. Private Label | 0.0512 | -114.35 | 13.38 |
| *p-values* | 0.000 | 0.001 | 0.000 |
| Non-Plastic Container | 0.0328 | -73.28 | -10.96 |
| *p-values* | 0.002 | 0.008 | 0.000 |
| White Skim milk | 0.0216 | -48.26 | 6.67 |
| *p-values* | 0.013 | 0.039 | 0.000 |
| White Lowfat milk | -0.00048 | 1.0787 | 9.03 |
| *p-values* | 0.968 | 0.968 | 0.000 |
| White Whole milk | -0.0270 | 60.33 | -1.15 |
| *p-values* | 0.004 | 0.018 | 0.052 |
| (dR/dP) from the NHPE = | | 0.00045 | |
| *p-value* | | 0.000 | |

See Figures 2,3 and 4 for definitions and explanation of the headings and acronyms.

Given these unusual conditions, the consumers' willingness to pay for branded quarts of milk is -114.35 cents. Since the hedonic price for the NHPE model requires quantity to remain fixed, a discount of 114.35 would have to be made on branded quarts to reduce quantity per transaction. Remember that in this case the relationship between the price and quantity is estimated to be positive. The WHPE model has no quantity relationship issues and is free from this effect. In addition, it has a positive average marginal valuation of 13.38 cents, implying that the overall transactions valuation of brand is 13.38 cents higher than that of the base.

The WHPE non-plastic containers hedonic price estimate is -10.96 cent less than the base container type, plastic. The NHPE price also is 73.29 lower than the base. The cheaper price of non-plastic containers the increased quantity per transaction, and the fixed quantity assumption, require that the estimated hedonic price be a discount of 73.28 cents.

The skim milk hedonic price for the WHPE model is a positive 6.67 cents and the NHPE willingness to pay for those who consumed skim milk is -48.26 cents, both relative to the base of reduced fat milk. Again, holding quantities constant, those that consume skim milk need to be willing to discount its value by 48.26 cents compared to two percent fat milk. The positive demand relationship forces the discount in order that quantity per transaction remain balanced.

Low-fat milk has a marginal attribute value of 9.03 cents, with a willingness to pay of 1.08 cents. The negative effect low-fat milk has on the transaction quantity assures that the willingness to pay is positive.

Whole milk in the quart size has an average marginal valuation of -1.15 cents, the willingness to pay for unchanged quantities was 60.33 cents more than the base reduced fat milk. The whole milk attribute decreases quantity per transaction relative to reduced fat milk, therefore the constant quantity assumption and positive demand relationship cause the willingness to pay of consumers to be positive relative to the base.

In a comparison of the WHPE estimates among the three container size models, differences can be seen between average attribute valuations. The attribute effects of brand and low-fat milk are positive for all container sizes. The container type attribute non-plastic is negative in the gallons and quarts models and positive for the half-gallon model. For skim milk, effects on average price are also mixed by size, with a negative effect for the gallon size and positive effects for the half-gallon and quart sizes. Whole milk has a negative effect on average price for the quart size, and a negative effect for both the gallon and half-gallon sizes. Only one effect is not statistically significant at the five percent level, that being whole milk in the quart size model.

Only the NHPE half-gallon and gallon models are compared. The quart model is not used since the estimate of dR/dP is positive, reversing the sign of the hedonic price estimates relative to the outcome of the other two models. The estimates for the two models are of like sign for the attributes of branded, container type, and whole milk. The branded hedonic prices for branded and non-plastic containers are positive, and those for whole milk are negative. The remaining two hedonic price estimates for the attributes skim and low-fat milk are opposite in sign. In both cases the half-gallon estimates for these two attributes are negative and the gallon estimates are positive.

The WHPE model estimates are considerably different, either in sign or magnitude for all considered attributes when compared to the NHPE model. This result really comes as no surprise considering the difference between the models. The WHPE model shows the effects characteristics have on price, while the NHPE model considers the effect characteristic have on quantity. These relationships are then translated into a hedonic price by holding quantity fixed and using the price quantity relationship to derive the consumers' willingness to pay.

General statements can be made about the effect of different container sizes. Container sizes with identical attributes do not have the same effect on consumers' willingness to pay, nor do they have the same effect on average marginal valuation. Container size does affect the magnitude and direction of hedonic values.

The NHPE quart size model gives rise to an anomalies result, a positive price quantity relationship, opposite of what is expected from theory. Some exploratory work using other functional forms, a logged income version and quadratic income term added to the models did not change the price quantity relationship. Further work on other years of data may prove helpful in determining if the result found here truly is an anomaly.

Identification plays a crucial role in determining the appropriate model. Nerlove's hedonic price estimates tell a story that relates to an adjustment for quantity considerations. Appropriately, these hedonic price estimates relate to the effect price plays in balancing a set quantity. Although not as simply understood as traditional or Waughian hedonic prices, the Nerlovian hedonic price estimates provide valuable information.

**Summary and Discussion**

Considering the identification problems associated with doing hedonic price estimation, hedonic prices were estimated for three different container sizes and five characteristics, using a quantity dependent hedonic model (Nerlove). Transactional data were used in the hedonic price estimation. The interpretation of the hedonic prices estimated in the Nerlove model is consistent with the demand theory concept of willingness to pay versus the price dependent system, which represents a marginal implicit price valuation of characteristics. The fat types, brand type, and container type are different in effect depending on container size.

This works supports Nerlove's contention that one must be careful when estimating a hedonic model, since incorrect application of methodology will result in very different estimates which have very different interpretation and may not be supported by economic theory.

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# APPENDIX A

## COEFFICIENT DESCRIPTION FOR BOTH THE NERLOVIAN AND WAUGHIAN HEDONIC MODELS AND COMPLETE HEDONIC MODEL RESULTS

**Table A1. Coefficient Description for Both the Nerlovian and Waughian Hedonic Models**

| Coefficient | Name | Definition |
|---|---|---|
| $\rho_p$ | UNTPRICE | Unit Price |
| $\beta_{1i}$ | AVGINC | Average Household Income |
| $\beta_{2i}$ | AGEF25 | Female head of household less then age 25 |
| $\beta_{3i}$ | AGEF50 | Female head of household between 40 and 65 years old |
| $\beta_{4i}$ | AGEF65 | Female head of household 65 years old or older |
| $\beta_{5i}$ | UNEMP | Female head of household unemployed |
| $\beta_{6i}$ | PTEMP | Female head of household employed, but less than 30 hours |
| $\beta_{7i}$ | EDUFH | Female head of household with a high school education or less |
| $\beta_{8i}$ | EDUFCP | Female head of household with a college degree |
| $\beta_{9i}$ | BLACK | Race type of black |
| $\beta_{10i}$ | OTHER | Race type other than black or white |
| $\beta_{11i}$ | HISPY | Hispanic ethnicity |
| $\beta_{12i}$ | NONMETRO | Household located outside of a city |
| $\beta_{13i}$ | EAST | Eastern Region of the U.S. |
| $\beta_{14i}$ | WEST | Western Region of the U.S. |
| $\beta_{15i}$ | CENTRAL | Central Region of the U.S. |
| $\beta_{16i}$ | WIDOWED | Martial Status in the household, widowed |
| $\beta_{17i}$ | DIVORCED | Martial Status in the household, divorced |
| $\beta_{18i}$ | SINGLE | Martial Status in the household, single |
| $\beta_{19i}$ | HS1 | A household of one person |
| $\beta_{20i}$ | HS2 | A household of two people |
| $\beta_{21ji}$ | HS3 | A household of three people |
| $\gamma_{1j}$ | JAN | Month of January |
| $\gamma_{2j}$ | FEB | Month of February |
| $\gamma_{3j}$ | MCH | Month of March |
| $\gamma_{4j}$ | APR | Month of April |
| $\gamma_{5j}$ | MAY | Month of May |
| $\gamma_{6j}$ | JNE | Month of June |
| $\gamma_{7j}$ | JLY | Month of July |
| $\gamma_{8j}$ | AUG | Month of August |
| $\gamma_{9j}$ | SEP | Month of September |
| $\gamma_{10j}$ | OCT | Month of October |
| $\gamma_{11j}$ | NOV | Month of November |
| $\alpha_{k1}$ | *BNAME* | Brand Type Characteristic |
| $\alpha_{k2}$ | *NTPLSTIC* | Container type characteristic |
| $\alpha_{k3}$ | *SKIM* | White skim milk (fat type) |
| $\alpha_{k4}$ | *LOWFAT* | White lowfat milk (fat type) |
| $\alpha_{k5}$ | *WHOLE* | White whole milk (fat type) |
| $\beta_0$ | CONSTANT | Intercept term, the value of the base scenario |

See Figure 2 and 3 for coefficient specification in equations.

**Table A2. Waughian Hedonic Model Results, Gallon-Size Container**

| Coefficient Name | Coefficient Estimate | Standard Error | t-statistic | p-value |
|---|---|---|---|---|
| AVGINC | 0.00 | 0.00 | 21.00 | 0.00 |
| AGEF25 | 4.46 | 0.33 | 13.70 | 0.00 |
| AGEF50 | -1.33 | 0.34 | -3.89 | 0.00 |
| AGEF65 | -5.03 | 0.52 | -9.75 | 0.00 |
| UNEMP | -1.38 | 0.32 | -4.36 | 0.00 |
| PTEMP | -1.13 | 0.34 | -3.28 | 0.00 |
| EDUFH | 2.67 | 0.32 | 8.24 | 0.00 |
| EDUFCP | -0.28 | 0.30 | -0.92 | 0.36 |
| BLACK | 1.33 | 0.61 | 2.19 | 0.03 |
| OTHER | 1.24 | 0.65 | 1.91 | 0.06 |
| HISPY | 1.81 | 0.58 | 3.11 | 0.00 |
| NONMETRO | -2.92 | 0.36 | -8.05 | 0.00 |
| EAST | -0.17 | 0.37 | -0.46 | 0.65 |
| WEST | 2.58 | 0.37 | 6.92 | 0.00 |
| CENTRAL | -14.11 | 0.33 | -42.36 | 0.00 |
| WIDOWED | 8.21 | 0.72 | 11.47 | 0.00 |
| DIVORCED | 2.54 | 0.51 | 4.93 | 0.00 |
| SINGLE | 4.06 | 0.60 | 6.75 | 0.00 |
| HS1 | 3.61 | 0.66 | 5.49 | 0.00 |
| HS2 | 2.45 | 0.34 | 7.14 | 0.00 |
| HS3 | 3.09 | 0.35 | 8.77 | 0.00 |
| JAN | 1.42 | 0.60 | 2.36 | 0.02 |
| FEB | 6.04 | 0.61 | 9.85 | 0.00 |
| MCH | 4.44 | 0.60 | 7.44 | 0.00 |
| APR | -21.62 | 0.61 | -35.65 | 0.00 |
| MAY | -18.66 | 0.60 | -30.98 | 0.00 |
| JNE | -17.06 | 0.61 | -27.83 | 0.00 |
| JLY | -17.66 | 0.61 | -29.04 | 0.00 |
| AUG | -22.24 | 0.61 | -36.58 | 0.00 |
| SEP | -12.72 | 0.61 | -20.72 | 0.00 |
| OCT | 5.74 | 0.61 | 9.41 | 0.00 |
| NOV | 11.11 | 0.62 | 17.88 | 0.00 |
| *BNAME* | *6.54* | *0.27* | *24.12* | *0.00* |
| *NTPLSTIC* | *-17.51* | *1.52* | *-11.53* | *0.00* |
| *SKIM* | *-6.71* | *0.32* | *-20.74* | *0.00* |
| *LOWFAT* | *0.83* | *0.36* | *2.29* | *0.02* |
| *WHOLE* | *14.94* | *0.36* | *41.75* | *0.00* |
| CONSTANT | 249.03 | 0.71 | 348.81 | 0.00 |

*Italics* indicate attribute variables. See Appendix A for parameter explanation.

**Table A3. Nerlovian Hedonic Model Results, Gallon-Size Container**

| Coefficient Name | Coefficient Estimate | Standard Error | t-statistic | p-value |
|---|---|---|---|---|
| *UNTPRICE* | *0.00* | *0.00* | *-31.34* | *0.00* |
| AVGINC | 0.00 | 0.00 | 6.35 | 0.00 |
| AGEF25 | -0.02 | 0.00 | -3.61 | 0.00 |
| AGEF50 | 0.01 | 0.00 | 2.09 | 0.04 |
| AGEF65 | -0.04 | 0.01 | -5.74 | 0.00 |
| UNEMP | 0.00 | 0.00 | -0.02 | 0.98 |
| PTEMP | -0.04 | 0.00 | -9.78 | 0.00 |
| EDUFH | -0.02 | 0.00 | -3.85 | 0.00 |
| EDUFCP | 0.01 | 0.00 | 1.82 | 0.07 |
| BLACK | -0.09 | 0.01 | -11.31 | 0.00 |
| OTHER | 0.03 | 0.01 | 3.88 | 0.00 |
| NONMETRO | -0.02 | 0.00 | -3.64 | 0.00 |
| EAST | -0.01 | 0.00 | -1.20 | 0.23 |
| WEST | 0.27 | 0.00 | 57.73 | 0.00 |
| CENTRAL | 0.06 | 0.00 | 13.17 | 0.00 |
| WIDOWED | 0.03 | 0.01 | 3.66 | 0.00 |
| DIVORCED | 0.01 | 0.01 | 0.89 | 0.37 |
| SINGLE | -0.04 | 0.01 | -5.04 | 0.00 |
| NOKIDS | -0.02 | 0.01 | -4.15 | 0.00 |
| HS1 | -0.27 | 0.01 | -29.18 | 0.00 |
| HS2 | -0.20 | 0.01 | -35.45 | 0.00 |
| HS3 | -0.09 | 0.00 | -19.47 | 0.00 |
| JAN | -0.03 | 0.01 | -4.08 | 0.00 |
| FEB | -0.01 | 0.01 | -1.74 | 0.08 |
| MCH | 0.00 | 0.01 | -0.65 | 0.51 |
| APR | -0.03 | 0.01 | -4.00 | 0.00 |
| MAY | -0.03 | 0.01 | -4.40 | 0.00 |
| JNE | -0.03 | 0.01 | -3.27 | 0.00 |
| JLY | -0.03 | 0.01 | -4.40 | 0.00 |
| AUG | -0.05 | 0.01 | -5.95 | 0.00 |
| SEP | -0.02 | 0.01 | -3.02 | 0.00 |
| OCT | -0.01 | 0.01 | -1.26 | 0.21 |
| NOV | 0.00 | 0.01 | 0.30 | 0.76 |
| *BNAME* | *0.02* | *0.00* | *6.59* | *0.00* |
| *NTPLSTIC* | *0.39* | *0.02* | *20.37* | *0.00* |
| *SKIM* | *0.02* | *0.00* | *4.14* | *0.00* |
| *LOWFAT* | *0.03* | *0.00* | *6.45* | *0.00* |
| *WHOLE* | *-0.03* | *0.00* | *-5.56* | *0.00* |
| CONSTANT | 1.57 | 0.01 | 127.82 | 0.00 |

*Italics* indicate attribute variables. See Appendix A for parameter explanation.

## Table A4. Waughian Hedonic Model Results, Half-Gallon-Size Container

| Coefficient Name | Coefficient Estimate | Standard Error | t-statistic | p-value |
|---|---|---|---|---|
| AVGINC | 0.00 | 0.00 | 16.83 | 0.00 |
| AGEF25 | 1.55 | 0.48 | 3.20 | 0.00 |
| AGEF50 | -0.73 | 0.43 | -1.67 | 0.09 |
| AGEF65 | 0.10 | 0.54 | 0.18 | 0.86 |
| BLACK | 9.94 | 0.62 | 15.99 | 0.00 |
| OTHER | 14.12 | 0.72 | 19.54 | 0.00 |
| NONMETRO | -9.85 | 0.45 | -21.73 | 0.00 |
| EAST | -17.95 | 0.41 | -43.31 | 0.00 |
| WEST | 13.31 | 0.48 | 27.82 | 0.00 |
| CENTRAL | -11.57 | 0.50 | -22.98 | 0.00 |
| WIDOWED | 2.27 | 0.63 | 3.59 | 0.00 |
| DIVORCED | 5.67 | 0.51 | 11.15 | 0.00 |
| SINGLE | 3.15 | 0.51 | 6.15 | 0.00 |
| NOKIDS | 2.25 | 0.43 | 5.19 | 0.00 |
| JAN | 0.13 | 0.76 | 0.17 | 0.87 |
| FEB | 1.13 | 0.77 | 1.46 | 0.14 |
| MCH | 3.85 | 0.76 | 5.04 | 0.00 |
| APR | -8.93 | 0.77 | -11.61 | 0.00 |
| MAY | -8.22 | 0.77 | -10.72 | 0.00 |
| JNE | -10.73 | 0.77 | -13.88 | 0.00 |
| JLY | -10.02 | 0.77 | -13.02 | 0.00 |
| AUG | -9.61 | 0.77 | -12.51 | 0.00 |
| SEP | -7.78 | 0.78 | -10.01 | 0.00 |
| OCT | 1.99 | 0.77 | 2.59 | 0.01 |
| NOV | 3.23 | 0.78 | 4.14 | 0.00 |
| *BNAME* | *20.70* | *0.33* | *62.56* | *0.00* |
| *NTPLSTIC* | *9.47* | *0.33* | *28.60* | *0.00* |
| *SKIM* | *8.39* | *0.39* | *21.28* | *0.00* |
| *LOWFAT* | *4.78* | *0.46* | *10.40* | *0.00* |
| *WHOLE* | *3.82* | *0.46* | *8.33* | *0.00* |
| CONSTANT | 149.66 | 0.87 | 171.97 | 0.00 |

*Italics* indicate attribute variables. See Appendix A for parameter explanation.

**Table A5. Nerlovian Hedonic Model Results, Half-Gallon-Size Container**

| Coefficient Name | Coefficient Estimate | Standard Error | t-statistic | p-value |
|---|---|---|---|---|
| *UNTPRICE* | *0.00* | *0.00* | *-25.76* | *0.00* |
| AVGINC | 0.00 | 0.00 | -16.05 | 0.00 |
| AGEF25 | -0.05 | 0.01 | -7.72 | 0.00 |
| AGEF50 | -0.02 | 0.01 | -3.57 | 0.00 |
| AGEF65 | -0.07 | 0.01 | -7.78 | 0.00 |
| UNEMP | 0.01 | 0.01 | 1.22 | 0.22 |
| PTEMP | -0.02 | 0.01 | -3.20 | 0.00 |
| EDUFH | -0.01 | 0.01 | -1.12 | 0.26 |
| EDUFCP | 0.03 | 0.01 | 5.24 | 0.00 |
| BLACK | -0.04 | 0.01 | -4.32 | 0.00 |
| OTHER | -0.05 | 0.01 | -4.42 | 0.00 |
| HISPY | -0.06 | 0.01 | -5.71 | 0.00 |
| NONMETRO | 0.05 | 0.01 | 8.68 | 0.00 |
| EAST | 0.01 | 0.01 | 1.07 | 0.29 |
| WEST | 0.11 | 0.01 | 16.97 | 0.00 |
| CENTRAL | 0.10 | 0.01 | 14.21 | 0.00 |
| WIDOWED | -0.07 | 0.01 | -7.14 | 0.00 |
| DIVORCED | -0.06 | 0.01 | -6.99 | 0.00 |
| SINGLE | -0.06 | 0.01 | -6.31 | 0.00 |
| NOKIDS | -0.04 | 0.01 | -4.39 | 0.00 |
| HS1 | -0.31 | 0.01 | -26.85 | 0.00 |
| HS2 | -0.24 | 0.01 | -28.93 | 0.00 |
| HS3 | -0.21 | 0.01 | -28.25 | 0.00 |
| JAN | -0.02 | 0.01 | -1.49 | 0.14 |
| FEB | 0.00 | 0.01 | -0.02 | 0.98 |
| MCH | -0.01 | 0.01 | -1.11 | 0.27 |
| APR | 0.03 | 0.01 | 2.92 | 0.00 |
| MAY | -0.02 | 0.01 | -2.00 | 0.05 |
| JNE | -0.01 | 0.01 | -0.88 | 0.38 |
| JLY | -0.01 | 0.01 | -1.14 | 0.25 |
| AUG | 0.00 | 0.01 | 0.43 | 0.67 |
| SEP | 0.00 | 0.01 | -0.45 | 0.65 |
| OCT | 0.01 | 0.01 | 1.03 | 0.30 |
| NOV | 0.04 | 0.01 | 3.58 | 0.00 |
| *BNAME* | *0.05* | *0.00* | *11.24* | *0.00* |
| *NTPLSTIC* | *0.08* | *0.00* | *17.02* | *0.00* |
| *SKIM* | *-0.02* | *0.01* | *-2.97* | *0.00* |
| *LOWFAT* | *-0.01* | *0.01* | *-1.89* | *0.06* |
| *WHOLE* | *-0.07* | *0.01* | *-10.49* | *0.00* |
| CONSTANT | 1.65 | 0.02 | 107.16 | 0.00 |

*Italics* indicate attribute variables. See Appendix A for parameter explanation.

**Table A6. Waughian Hedonic Model Results, Quart-Size Container**

| Coefficient Name | Coefficient Estimate | Standard Error | t-statistic | p-value |
|---|---|---|---|---|
| AVGINC | 0.00 | 0.00 | 1.24 | 0.22 |
| AGEF25 | -1.45 | 0.73 | -1.98 | 0.05 |
| AGEF50 | 3.09 | 0.60 | 5.10 | 0.00 |
| AGEF65 | 2.67 | 0.72 | 3.74 | 0.00 |
| EDUFH | 3.03 | 0.59 | 5.16 | 0.00 |
| EDUFCP | 1.53 | 0.53 | 2.88 | 0.00 |
| BLACK | 5.08 | 0.70 | 7.29 | 0.00 |
| OTHER | 8.26 | 0.86 | 9.57 | 0.00 |
| NONMETRO | -12.84 | 0.67 | -19.10 | 0.00 |
| EAST | -22.19 | 0.57 | -39.00 | 0.00 |
| WEST | 6.83 | 0.64 | 10.60 | 0.00 |
| CENTRAL | -1.50 | 0.72 | -2.08 | 0.04 |
| WIDOWED | 2.39 | 0.87 | 2.75 | 0.01 |
| DIVORCED | 2.44 | 0.81 | 3.01 | 0.00 |
| SINGLE | 4.45 | 0.79 | 5.60 | 0.00 |
| HS1 | -5.38 | 1.04 | -5.16 | 0.00 |
| HS2 | -0.75 | 0.82 | -0.92 | 0.36 |
| HS3 | 3.82 | 0.96 | 4.00 | 0.00 |
| JAN | 0.47 | 1.05 | 0.45 | 0.65 |
| FEB | 1.26 | 1.06 | 1.19 | 0.23 |
| MCH | 1.18 | 1.04 | 1.14 | 0.25 |
| APR | -3.77 | 1.05 | -3.58 | 0.00 |
| MAY | -4.62 | 1.04 | -4.44 | 0.00 |
| JNE | -4.54 | 1.05 | -4.32 | 0.00 |
| JLY | -4.35 | 1.04 | -4.17 | 0.00 |
| AUG | -4.99 | 1.05 | -4.77 | 0.00 |
| SEP | -4.17 | 1.05 | -3.98 | 0.00 |
| OCT | 1.74 | 1.04 | 1.67 | 0.09 |
| NOV | 1.93 | 1.07 | 1.80 | 0.07 |
| *BNAME* | *13.38* | *0.45* | *29.62* | *0.00* |
| *NTPLSTIC* | *-10.96* | *0.65* | *-16.75* | *0.00* |
| *SKIM* | *6.67* | *0.55* | *12.15* | *0.00* |
| *LOWFAT* | *9.03* | *0.76* | *11.88* | *0.00* |
| *WHOLE* | *-1.15* | *0.59* | *-1.94* | *0.05* |
| CONSTANT | 115.12 | 1.46 | 78.66 | 0.00 |

*Italics* indicate attribute variables. See Appendix A for parameter explanation.

**Table A7. Nerlovian Hedonic Model Results, Quart-Size Container**

| Coefficient Name | Coefficient Estimate | Standard Error | t-statistic | p-value |
|---|---|---|---|---|
| *UNTPRICE* | *0.00* | *0.00* | *4.16* | *0.00* |
| AVGINC | 0.00 | 0.00 | -7.06 | 0.00 |
| AGEF25 | -0.02 | 0.01 | -2.01 | 0.04 |
| AGEF50 | 0.01 | 0.01 | 1.45 | 0.15 |
| AGEF65 | -0.04 | 0.01 | -2.98 | 0.00 |
| UNEMP | 0.05 | 0.01 | 5.29 | 0.00 |
| PTEMP | -0.03 | 0.01 | -2.87 | 0.00 |
| EDUFH | 0.02 | 0.01 | 2.13 | 0.03 |
| EDUFCP | 0.07 | 0.01 | 8.53 | 0.00 |
| BLACK | 0.03 | 0.01 | 2.85 | 0.00 |
| OTHER | 0.02 | 0.01 | 1.11 | 0.27 |
| NONMETRO | 0.04 | 0.01 | 3.59 | 0.00 |
| EAST | -0.01 | 0.01 | -1.47 | 0.14 |
| WEST | 0.03 | 0.01 | 3.19 | 0.00 |
| CENTRAL | 0.02 | 0.01 | 2.04 | 0.04 |
| WIDOWED | 0.06 | 0.01 | 4.59 | 0.00 |
| DIVORCED | 0.04 | 0.01 | 3.11 | 0.00 |
| SINGLE | 0.04 | 0.01 | 2.89 | 0.00 |
| NOKIDS | -0.05 | 0.02 | -3.36 | 0.00 |
| HS1 | -0.16 | 0.02 | -8.34 | 0.00 |
| HS2 | -0.10 | 0.02 | -6.15 | 0.00 |
| HS3 | -0.07 | 0.02 | -4.70 | 0.00 |
| *BNAME* | *0.05* | *0.01* | *7.08* | *0.00* |
| *NTPLSTIC* | *0.03* | *0.01* | *3.17* | *0.00* |
| *SKIM* | *0.02* | *0.01* | *2.50* | *0.01* |
| *LOWFAT* | *0.00* | *0.01* | *-0.04* | *0.97* |
| *WHOLE* | *-0.03* | *0.01* | *-2.90* | *0.00* |
| CONSTANT | 1.11 | 0.02 | 45.57 | 0.00 |

*Italics* indicate attribute variables. See Appendix A for parameter explanation.

**Table A8. Goodness-of-Fit Measures for the Hedonic Models**

| Model | R-Square |
|---|---|
| Waughian Gallon-size | 0.11 |
| Nerlovian Gallon-size | 0.07 |
| Waughian Half-Gallon-size | 0.14 |
| Nerlovian Half-Gallon-size | 0.07 |
| Waughian Quart Size | 0.19 |
| Nerlovian Quart Size | 0.03 |