

CHAPTER IV: *Weekly Retail Meat Price and Quantity Data – An Empirical Analysis of Retail Scanner Data*

Weekly retail price and quantity data for five cuts of beef were obtained for sales of a grocery chain and detailed data for two stores within that chain.¹ The first objective of this chapter is to describe the nature and characteristics of unaggregated, weekly retail meat prices. The second objective is to show the effects of using true data in place of the historical retail meat price data in the calculation of elasticity parameters, as well as the variances and means of a quantity-weighted retail meat price series using weekly prices and quantities that are reported as is (i.e. not aggregated up to monthly, quarterly, or yearly averages).

4.1. A Summary and General Overview of the Data

The data available for each of the five cuts of meat – Select boneless ribeye steak, Select boneless top loin steak, Select boneless top round steak, Select porterhouse steak, and ground beef (75% lean) – consist of weekly price (\$/lb) and weekly quantity (lbs) information at the store level and for the chain over a period of 52 weeks starting on 09/10/2000 and ending on 09/02/2001. At the store level, data for five cuts of beef were obtained for two stores in a large metropolitan area. Due to the proprietary nature of the data, it was not possible to obtain any retail price and quantity data for substitute meats such as pork and chicken, nor any associated socio-economic and demographic measures, such as income, for the chain or for any of the stores. All data are found in Appendix B.

¹ The initial scanner data showed chain-wide sales for the five selected cuts. Major changes in week-to-week volumes with no significant change in price suggested problems, and further investigation revealed that the number of stores reporting each week was not controlled and varied over a wide range. With these chain-wide data, therefore, largely useless for analytical purposes, a second request for data set across stores that reported each week brought the data from two stores.

4.1.1. Select Boneless Ribeye Steak

In both stores, the weekly average price ranges from a low of \$3.98/lb to a high price of \$7.99/lb, and prices in the two stores are often the same or nearly the same. The smallest weekly quantity of ribeye steak purchased in Store One is 12 lbs and the largest is 898 lbs (Figure 4.1). In Store Two the weekly quantity purchased ranges from a low of 1lbs to a high of 1,306lbs (Figure 4.2). A lot of variation occurs in the quantity of ribeye steak purchased from week to week, in each store and between the stores, even at the same price level.

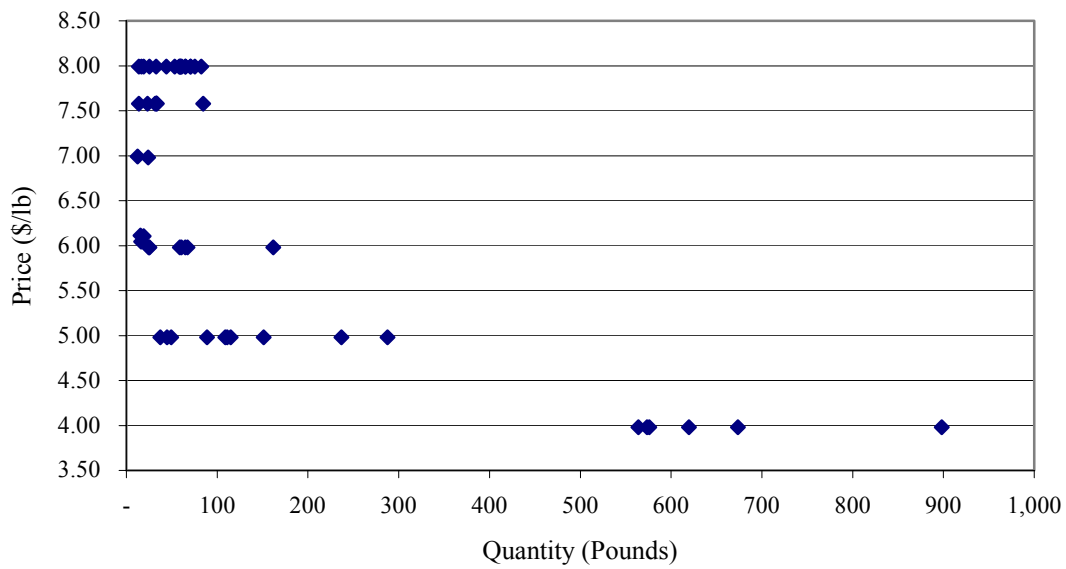


Figure 4.1. Price-Quantity Scatter Plot for Select Boneless Ribeye Steak in Store One over the 52-week period 09/10/200 to 09/02/2001.

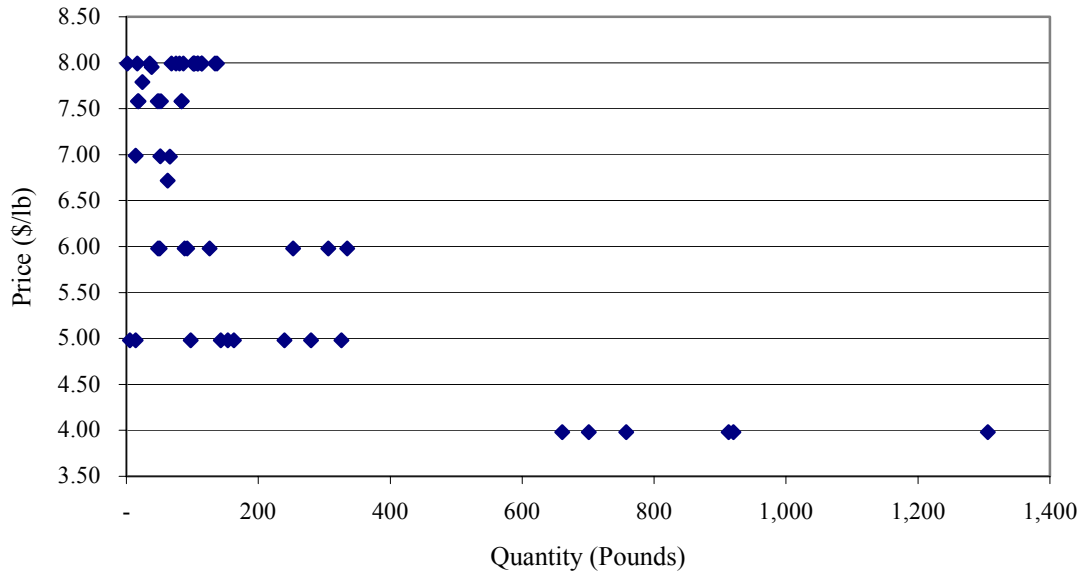


Figure 4.2. Price-Quantity Scatter Plot for Select Boneless Ribeye Steak in Store Two over the 52-week period 09/10/2000 to 09/02/2001.

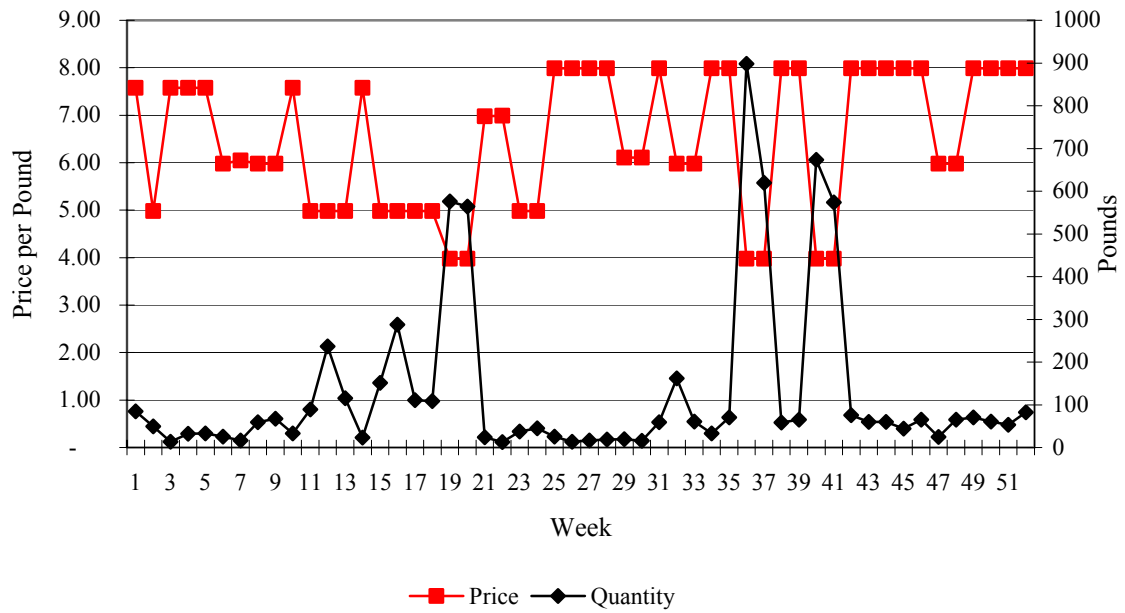


Figure 4.3. Price and Quantity Interactions for Select Boneless Ribeye Steak in Store One from 09/10/2000 to 09/02/2001.

From these graphs an apparent threshold of \$3.98/lb in both stores triggers a change in the quantity of ribeye steak purchased, with a lesser effect at a price of \$5.00/lb. In Store One, the quantity of ribeye steak purchased spiked noticeably at the \$3.98/lb price threshold in weeks 19, 20, 36, 37, 40, and 41 (Figure 4.3). Similar spikes in the quantity purchased occurred in Store Two in the same weeks when the price was also lowered to the \$3.98/lb level (Figure 4.4). Otherwise, there appears to be limited interaction between price and quantity for Select boneless ribeye steak.

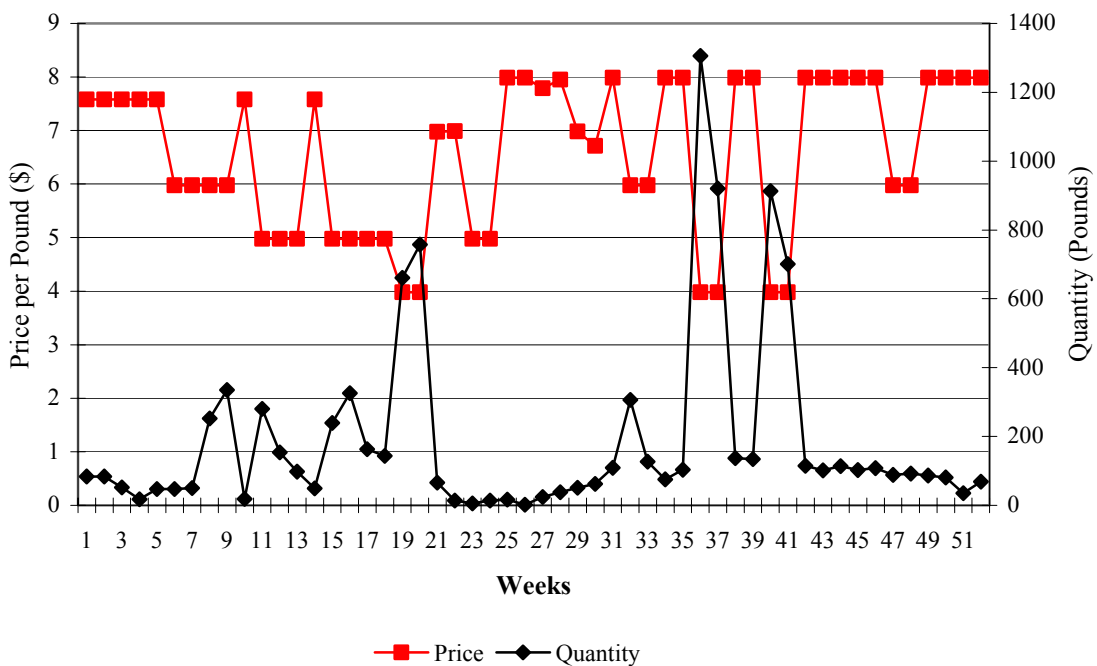


Figure 4.4. Price and Quantity Interactions for Select Boneless Ribeye Steak in Store Two from 09/10/2000 to 09/02/2001.

4.1.2. Select Boneless Top Loin Steak

In both Stores One and Two, the price per pound for Select boneless top loin steak ranges from \$3.98 to \$8.49, with the high price occurring in both stores in the same week. In Store One the quantity of top loin steak purchased weekly varies from as little as 5 lbs to 800 lbs (Figure 4.5). The vast majority of weekly purchases in Store One fall in the 0-100 pound category regardless of price. For Store Two over the same period, the smallest quantity purchased of top loin steak in a week is 16 lbs while the largest quantity

is 1,134 lbs (Figure 4.6). In Store Two the quantity purchased of top loin steak is responsive over a broader price range.

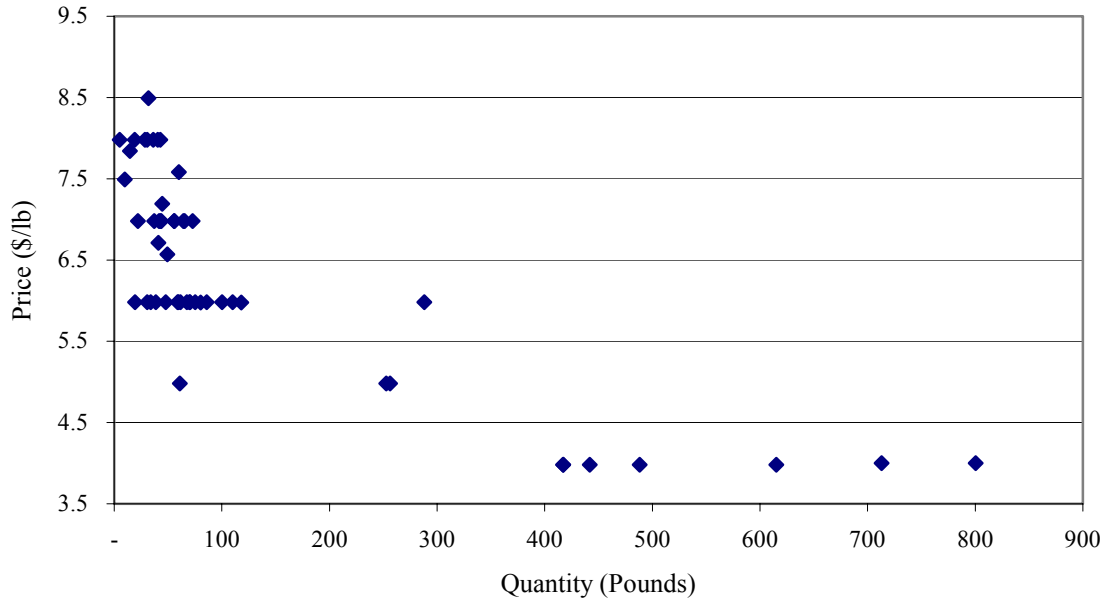


Figure 4.5. Price-Quantity Scatter Plot for Select Boneless Top Loin Steak in Store One over the 52-week period from 09/10/2000 to 09/02/2001.

The threshold for price quantity interaction for Select boneless top loin steak is similar to that of Select boneless ribeye steak at \$3.98/lb, with an apparent threshold occurring at the \$5.98/lb level as well. The price of \$3.98/lb in weeks 7, 10, 11, 25, 26, 45, and 46 triggered very large purchase responses in both stores (Figures 4.7 and 4.8). The data for Store Two also indicated a quantity interaction at the \$5.98/lb price level for four periods during the 52-week study period, namely weeks 1, 2, 22, and 23.

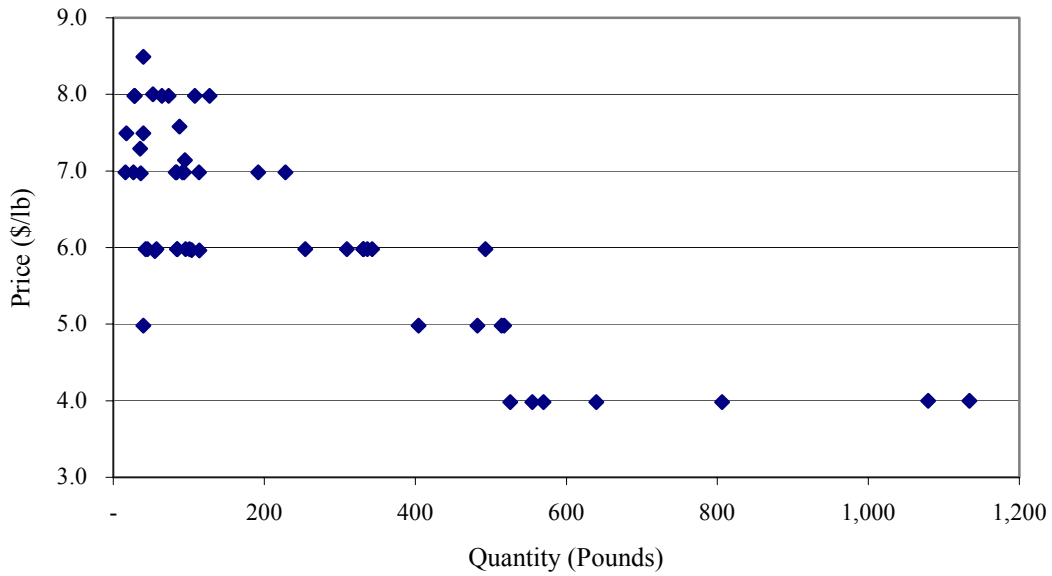


Figure 4.6. Price-Quantity Scatter Plot for Boneless Top Loin Steak in Store Two over the 52-week period from 09/10/2000 to 09/02/2001.

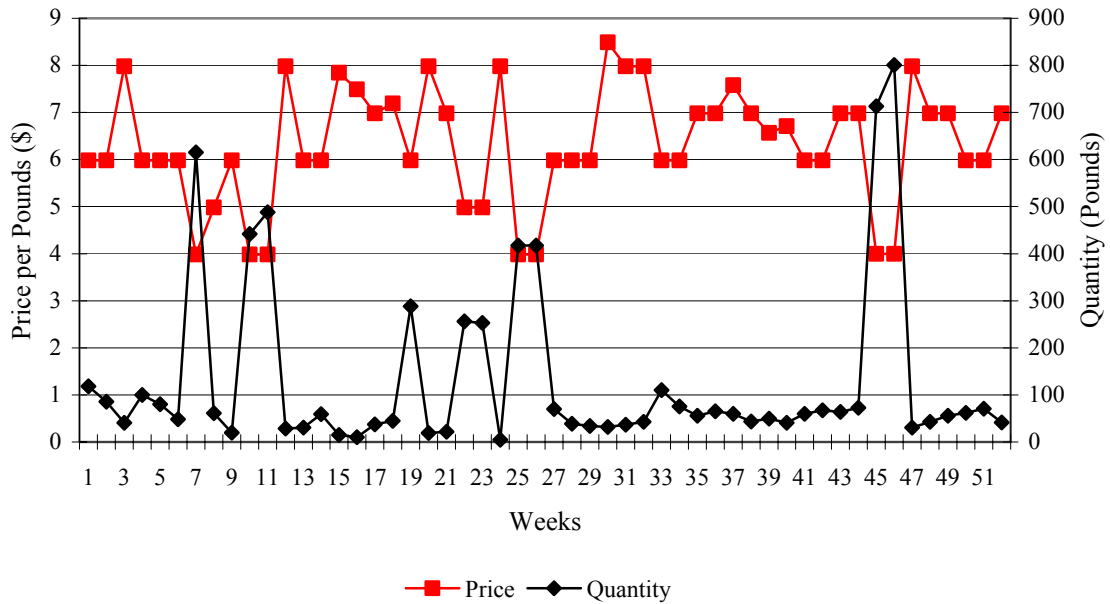


Figure 4.7. Price-Quantity Interactions for Select Boneless Top Loin Steak in Store One from 09/10/2000 to 09/02/2001.

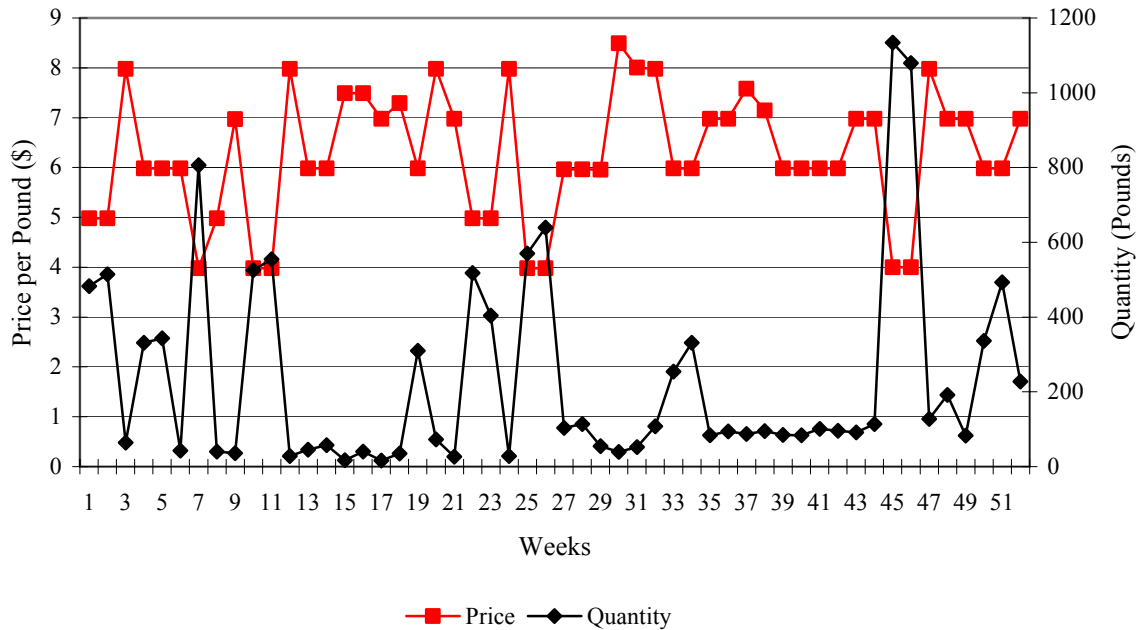


Figure 4.8. Price-Quantity Interactions for Select Boneless Top Loin Steak in Store Two from 09/10/2000 to 09/02/2001.

4.1.3. Select Boneless Top Round Steak

Select boneless top round steak over the 52-week period in Stores One and Two does not appear to respond as expected *a priori* as regards the interaction of prices and quantities (Figure 4.9 and 4.10). In both of these figures there is no clear “demand schedule.”

No reasonable explanation for this pattern in the data can be given at this point, and neither can any inferences be made about the data as there is not enough information available regarding the price collection process, the weeks in which pricing specials and/or advertisements were in place, and what price is actually collected at the point of payment. The reference is to possible aberrations in the final reported price data for any and all of the cuts because the UPC codes are not adjusted to reflect “buy one get one free” price specials, or price specials that only apply to customers that hold a special store card that entitles them to certain exclusive price discounts and specials.

Moreover, the per pound prices for top round steak in Stores One and Two are much lower than for ribeye and top loin steak. In both stores, the highest price charged over the 52-week period is \$4.99/lb while the prices drop to \$2.99/lb at the low end of the scale. The quantities purchased of top round steak are also significantly lower for this cut than for the previous two cuts with the total quantity purchased in either store in a given week never exceeding 35 pounds.

Figures 4.11 and 4.12 clearly illustrate a lack of pricing variation across the 52 weeks for this meat cut. However, when price is reduced, the reduction is by a considerably smaller percentage than is the case with the ribeye and top loin cuts. There does appear to be less correlation between price and quantity for this cut.

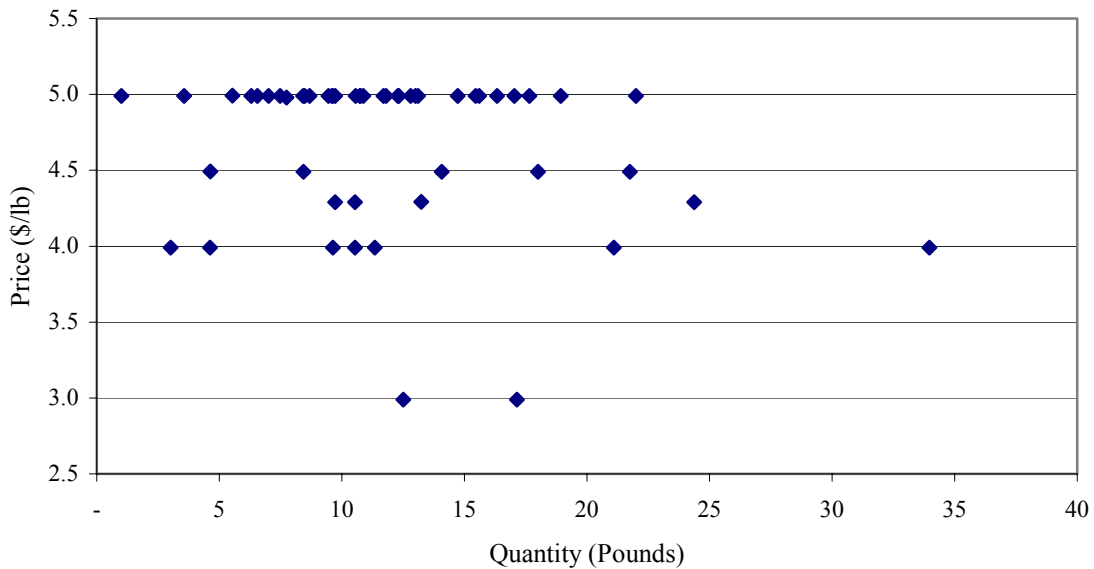


Figure 4.9. Price-Quantity Scatter Plot for Select Boneless Top Round Steak in Store One over the 52-week period from 09/10/2000 to 09/02/2001.

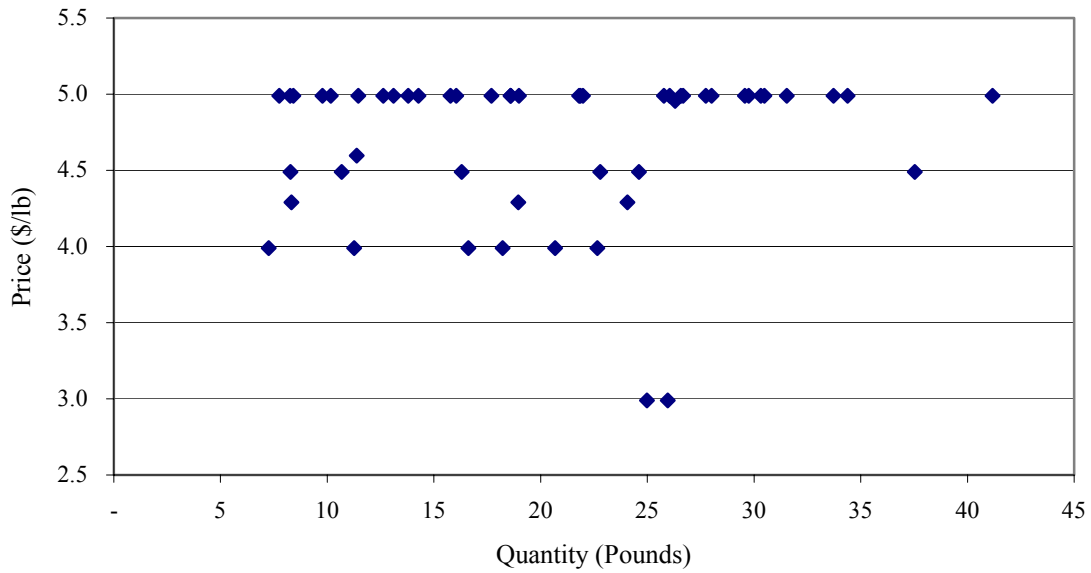


Figure 4.10. Price-Quantity Scatter Plot for Select Boneless Top Round Steak in Store Two over the 52-week period from 09/10/2000 to 09/02/2001.

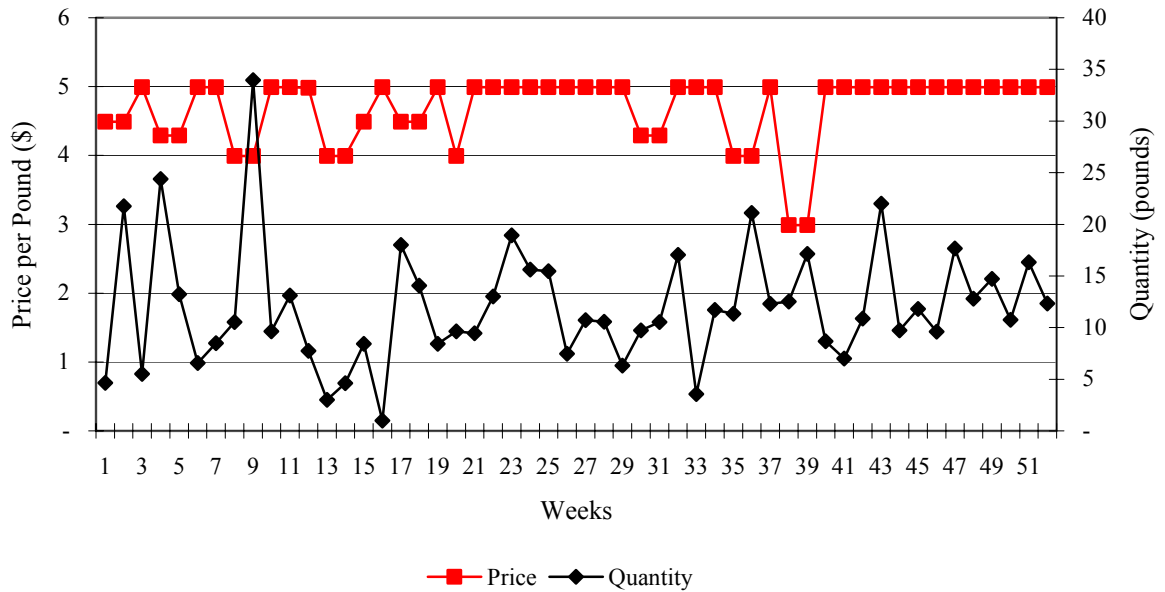


Figure 4.11. Price-Quantity Interactions for Select Boneless Top Round Steak in Store One from 09/10/2000 to 09/02/2001.

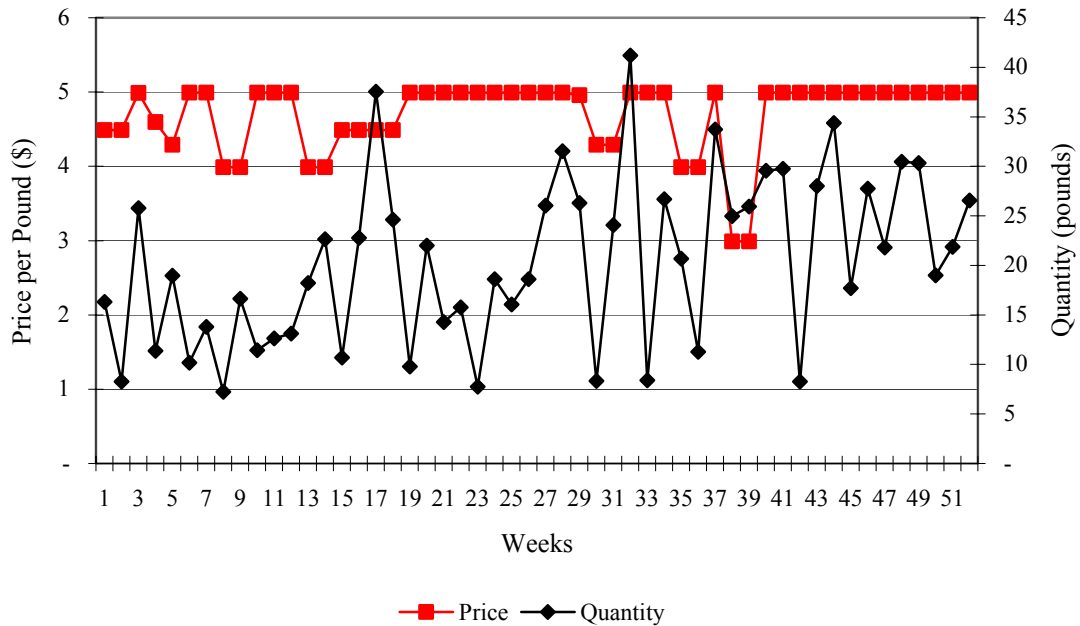


Figure 4.12. Price-Quantity Interactions for Select Boneless Top Round Steak in Store Two from 09/10/2000 to 09/02/2001.

4.1.4. Select Porterhouse Steak

The price-quantity scatter plots for Select porterhouse steak are very similar for Store One and Store Two (Figures 4.13 and 4.14). Both plots show the existence of a negative relationship between price and quantity. Porterhouse steak clearly illustrates the economic law of well-behaved demand. The highest price charged per pound for porterhouse steak in Store One is \$8.05/lb and \$8.03/lb in Store Two. The price does not fall below \$3.99/lb in either store over the 52-week period. The quantity of porterhouse steak purchased in both stores fluctuates a lot between the very high (1,186 lbs in Store One and 1,315 lbs in Store Two) and the very low (19 lbs and 7 lbs in Store One and Store Two, respectively) from week to week.

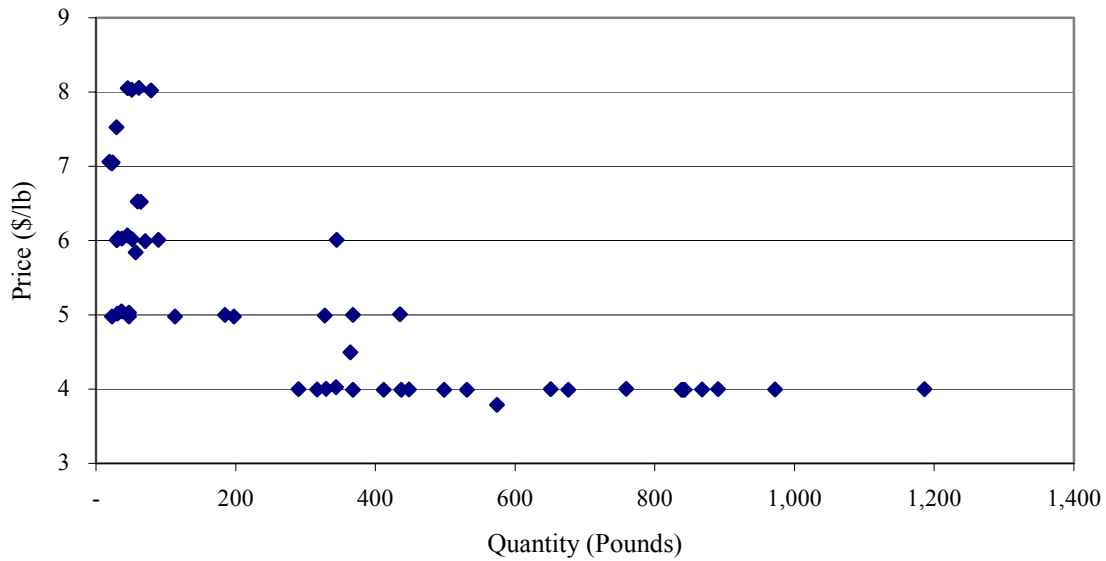


Figure 4.13. Price-Quantity Scatter Plot for Select Porterhouse Steak in Store One over the 52-week period from 09/10/2000 to 09/02/2001.

An examination of Figures 4.15 and 4.16 draws attention to the fact that, as with top round steak, the price and quantity data for porterhouse steak are highly variable over the data collection period. The price per pound for porterhouse steak is characterized by tremendous oscillation in both stores, with no apparent explanation or rationale.

A price threshold seems to exist at the \$3.79-4.00/lb price level, and to a lesser extent at the \$4.98/lb price level, that triggers an increased quantity response. Noticeably, very large peaks in associated purchases of porterhouse steak occur in both stores in weeks 1, 5, 38-39, 41-44, 48, and 51 as well as in weeks 17 and 18 in Store Two at the \$3.79-4.00/lb price level. These price-quantity responses for porterhouse steak are not as pronounced as is the case with both Select boneless ribeye steak and Select boneless top round steak. Possibly, Select porterhouse steak is used as a price special with the frequent prices at the \$4.00 level. The range in the quantities sold could have been influenced by newspaper advertisements, but requested data on when the stores ran advertisements provided no insights into the reasons for the large quantity variation evidenced with this meat cut.

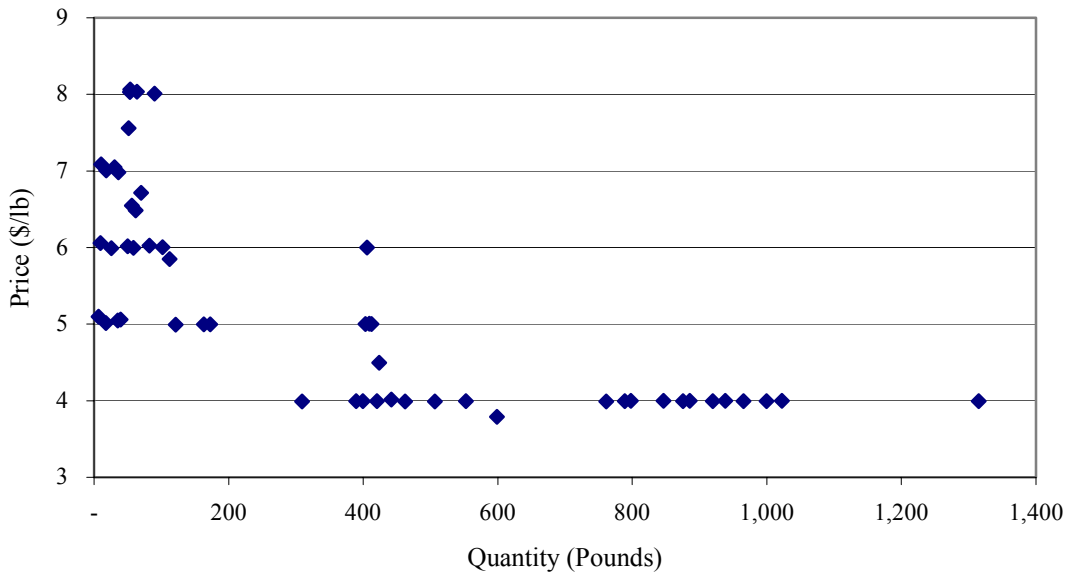


Figure 4.14. Price-Quantity Scatter Plot for Select Porterhouse Steak in Store Two over the 52-week period from 09/10/2000 to 09/02/2001.

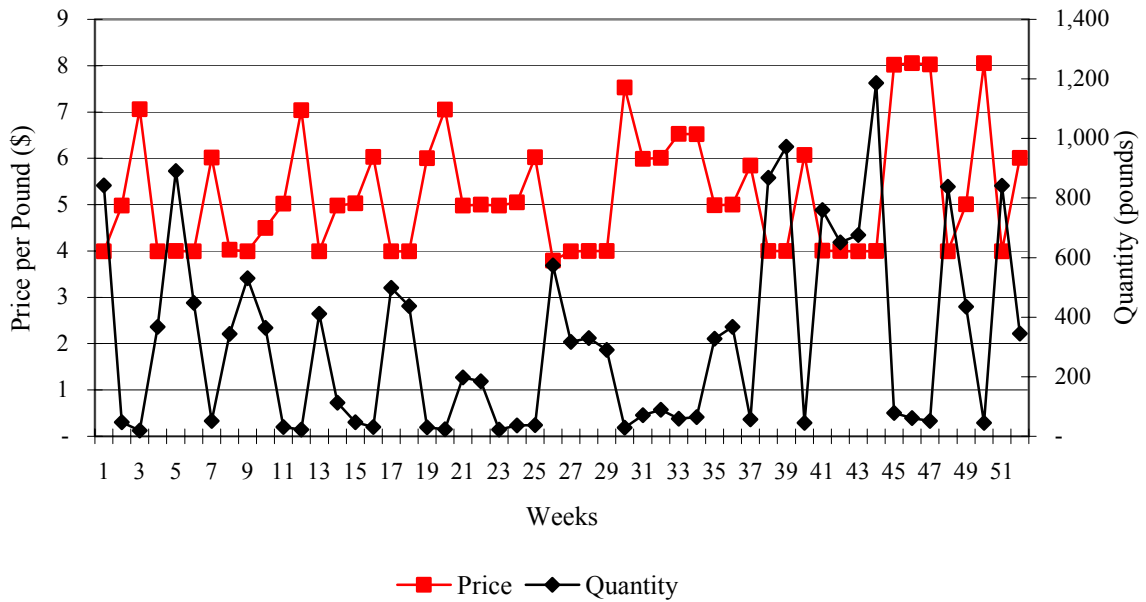


Figure 4.15. Price-Quantity Interactions for Select Porterhouse Steak in Store One from 09/10/2000 to 09/02/2001.

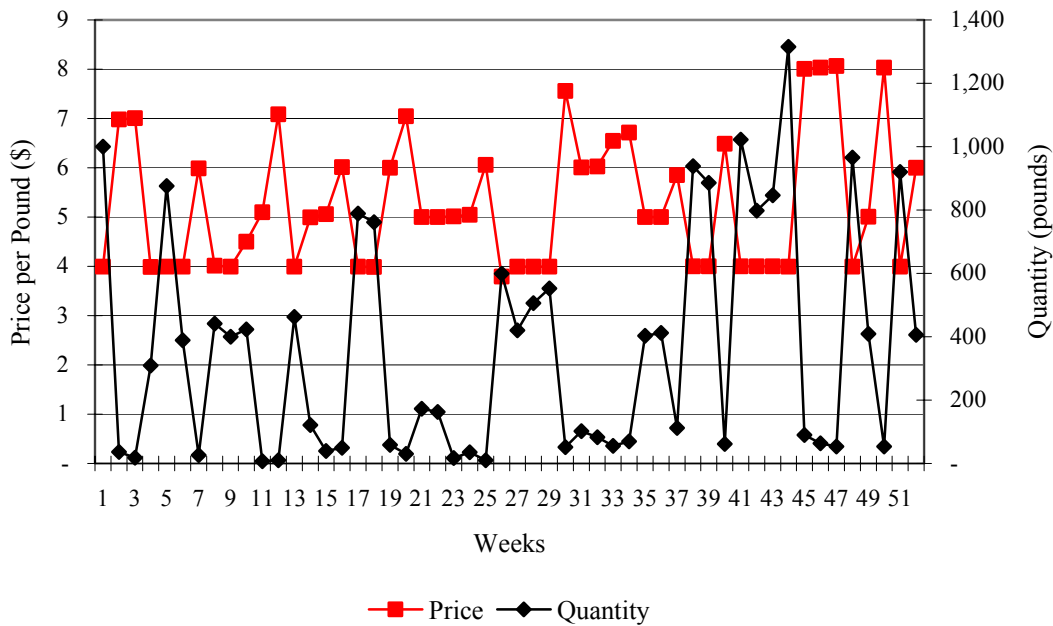


Figure 4.16. Price-Quantity Interactions for Select Porterhouse Steak in Store Two from 09/10/2000 to 09/02/2001.

4.1.5. Ground Beef (75% Lean)

Ground beef (75% lean) is characterized by a distinct and discontinuous response to price with a greater quantity response at the \$1.00/lb price level occurring in Store One than in Store Two. In Store One the lowest and highest prices over the 52-week reporting period are \$1.01/lb and \$2.60/lb, respectively. The largest weekly quantity purchased of ground beef in Store One is 1,065 lbs while the smallest weekly quantity sold is 75 lbs (Figure 4.17). In Store Two the prices range from a low of \$1.01/lb to a high of \$2.60/lb. The minimum weekly quantity of ground beef sold in Store Two is 177 lbs and the highest quantity sold over the 52 week period in any given week is 1,732 lbs (Figure 4.18).

The prices reported for all 52 weeks of data are not continuous through the \$1.00-\$1.50/lb price range (Figures 4.19 and 4.20). The possible quantity response in this price range is, therefore, unknown. Other than the interaction at the \$1.00/lb price level, there does appear to be less correlation at other price “discount” observations between price and quantity.

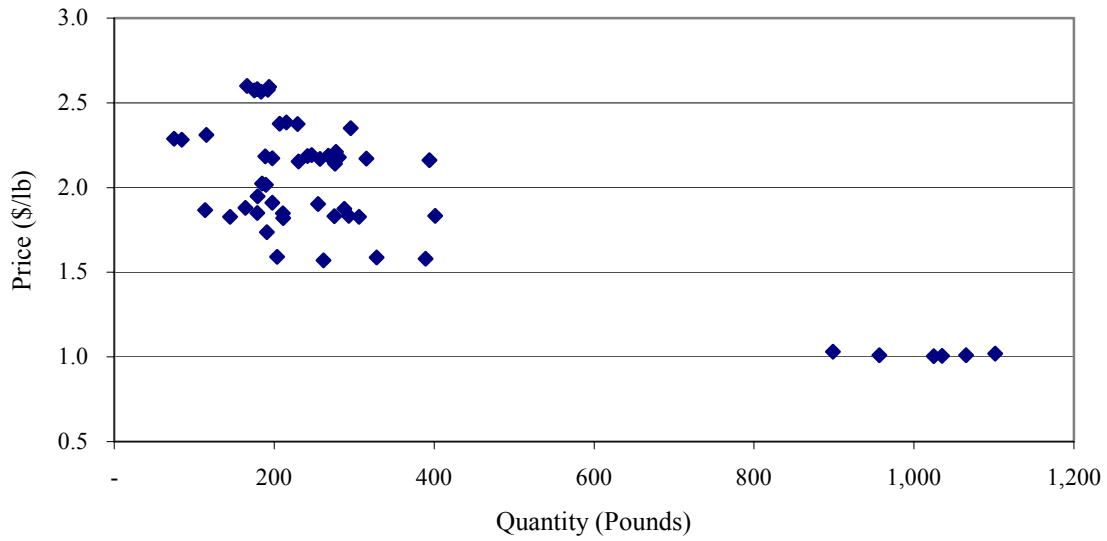


Figure 4.17. Price-Quantity Scatter Plot for Ground Beef (75% Lean) in Store 1 over the 52-week period from 09/10/2000 to 09/02/2001.

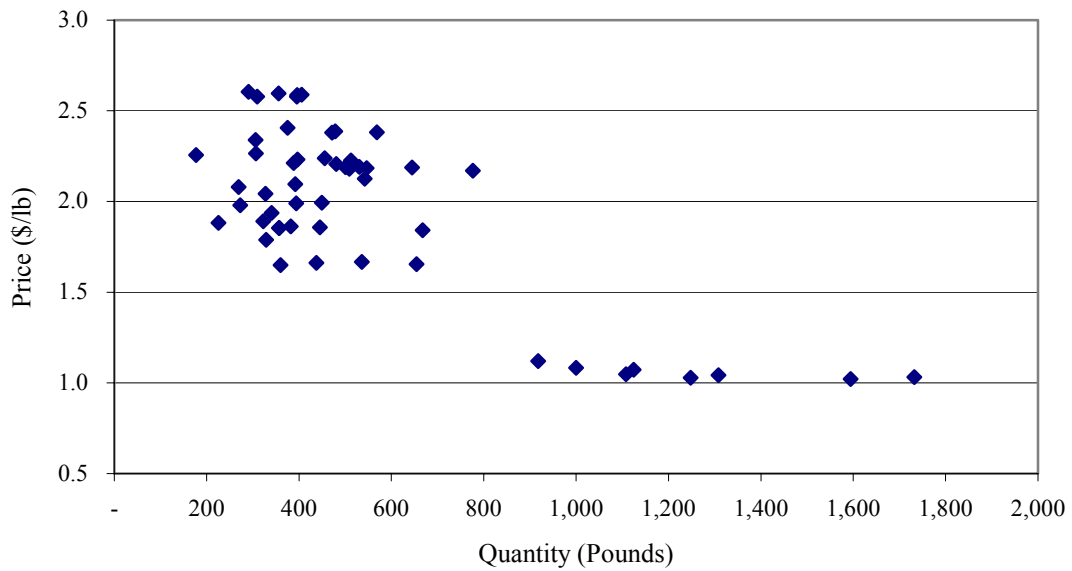


Figure 4.18. Price-Quantity Scatter Plot for Ground Beef (75% Lean) in Store 2 over the 52-week period from 09/10/2000 to 09/02/2001.

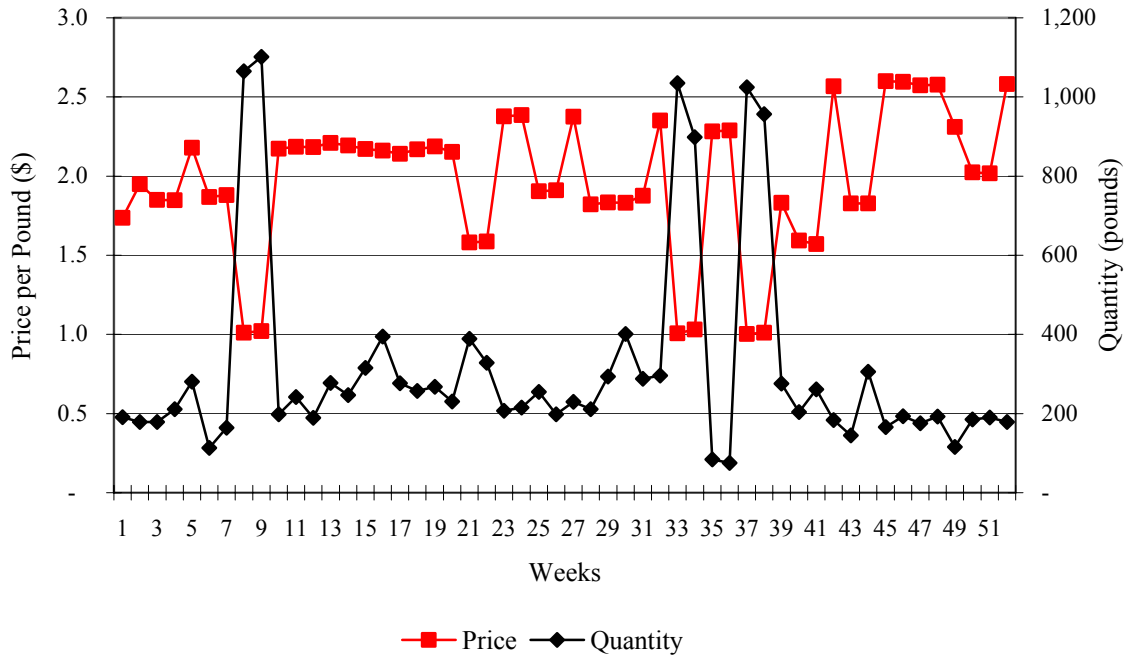


Figure 4.19. Price-Quantity Interactions for Ground Beef (75% Lean) in Store One from 09/10/2000 to 09/02/2001.

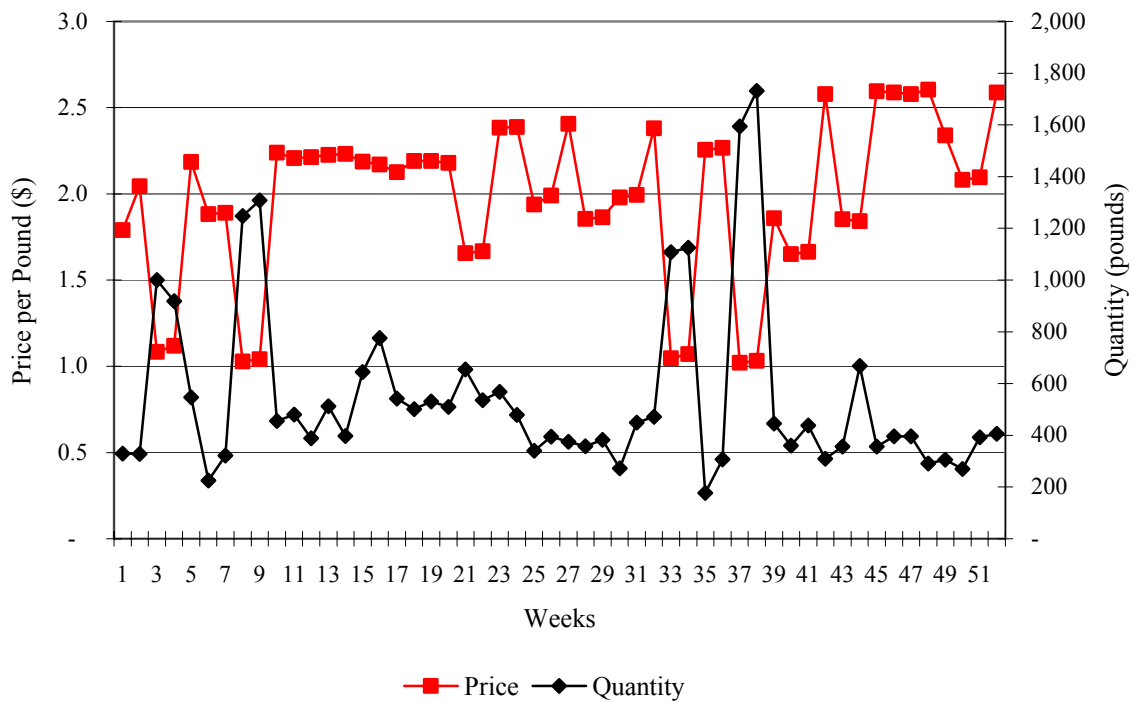


Figure 4.20. Price-Quantity Interactions for Ground Beef (75% Lean) in Store Two from 09/10/2000 to 09/02/2001.

4.2. Purpose of Data Analysis

The estimation and evaluation of the weekly store-level price and quantity data, described above, aims to satisfy several objectives. One of the primary considerations under the Mandatory Price Reporting Legislation is that of reporting a quantity-weighted prices series in place of a simple average price series, and what impact this might have on applied analysis and estimation of the demand for beef through the supply chain. Thus, the following data analysis considers the impact of using a quantity-weighted prices series on the mean, variance, and own-price elasticity of demand calculated from a quantity-weighted price series as opposed to calculating these statistical measures from a simple average price series. The intent is to establish and quantify any implications, which might arise, for the manner in which the historical meat price series data are to be reported in the future.

4.3. A Description of the Methods and Procedures used in the Analysis of Store Level Retail Meat Price and Quantity Data

4.3.1. Calculating Simple Average and Quantity Weighted Average Price Series

Using the 52 weekly price and quantity data observations, a monthly series consisting of simple average and a monthly series consisting of quantity-weighted average prices were calculated for the 52-week period for each store for each of the five cuts of beef. The prices obtained from the two methods of determining an average price across the price series were then compared to test the hypothesis that a quantity-weighted price is lower than a simple average price.

Each monthly price observation within the simple average price series was calculated by simply averaging four weekly prices.

$$\text{Monthly Simple Average Price} = \frac{\sum_{i=1}^4 P_i}{n}$$

Where $n = 4$ weeks.

In contrast, to calculate the weekly quantity-weighted price series, each of the prices in the series were weighted according to the quantity of product sold at that price.

$$\text{Monthly Quantity Weighted Price} = \frac{\sum_{i=1}^4 P_i Q_i}{\sum_{i=1}^4 Q_i}$$

4.3.2. The Data Modeling Approaches

The demand schedules for Select boneless ribeye steak, Select boneless top loin steak, Select porterhouse steak, and 75% lean ground beef all exhibited a general linear trend. Thus, various models were applied to and regressions run on the simple average and quantity-weighted monthly price series generated by the means described above. The models are fitted to the data for both stores for each of the five meat classes and elasticities calculated from the values obtained for the model parameters.

4.3.2.1. Models Fitted to the Data

A linear model, a logarithmic model (natural logs),² and a quadratic model were fitted to monthly simple average price series and monthly quantity-weighted price series. The two methods of aggregating to monthly prices allows for the examination of the impact of aggregation.

² Apart from endeavoring to discover a model that best fits the data, another reason why the log model was used is that the coefficient generated for the explanatory variable price in a quantity dependent model is an estimate of the own-price elasticity.

The own-price elasticities³ generated from these models were compared at the means for different impact by price series (simple versus weighted), by store, and by beef cut.

1. Linear Model

In equation format, the linear model fitted to the retail price and quantity data for each cut of beef can be written as

$$Q_{ij} = \alpha + \beta P_{ij} + \mu_{ij}$$

Where i = Store One or Two

j = beef cut (Select boneless ribeye, etc.)

Q = quantity purchased/consumed (lbs) of a particular cut of beef

P = nominal price (\$/lb) of a particular cut of beef

α = intercept

β = slope coefficient i.e $\Delta Q/\Delta P$

μ = error term

To calculate the own-price elasticity from the estimation of the linear model, the following equation is used:

$$\varepsilon = \frac{\Delta Q}{\Delta P} \times \frac{\bar{P}}{\bar{Q}}$$

where $\beta = \frac{\Delta Q}{\Delta P}$ for the linear model.

³ The intention is not to present the elasticity estimates as new estimates to be compared to historical research. The simple models do not include income, price of other meats, etc. as explanatory variables so that the presence of other economic forces would be accounted for. The results should, therefore, be seen as a first approximation of the impacts of quantity weighting of prices.

2. Log-Linear Model

In equation format, the log-linear model fitted to the computed monthly simple average and quantity weighted price series and monthly quantity store-level data for all the meat cuts can be expressed as⁴

$$\ln Q_{ij} = \alpha + \beta \ln P_{ij} + \mu_{ij}$$

where \ln = natural log

i = Store One or Two

j = beef cut (Select boneless ribeye steak, etc.)

Q = quantity purchased/consumed (lbs) of a particular cut of beef

P = price (\$/lb) of a particular cut of beef

α = intercept

β = elasticity of Q with respect to P , i.e. own-price elasticity

μ = error term

where $\varepsilon = \beta$ for the log-linear model.

3. The Quadratic Model

In equation form, the quadratic function, or more generally, a second-degree polynomial in the variable P , used to regress the monthly quantity data in each store first against the monthly simple average price data and then the monthly quantity-weighted data, can be written as⁵

$$Q_{ij} = \alpha + \beta_1 P_{ij} + \beta_2 P_{ij}^2 + \mu_{ij}$$

⁴ Alternatively, this model can be expressed as: $Q_{ij} = \alpha P_{ij}^\beta e^{\mu_{ij}}$

⁵ In these types of polynomial regressions, there is only one type of explanatory variable on the right-hand side of the function; however, it appears with various powers, thereby making them multiple regression models.

Where i = Store One or Two

j = beef cut (Select boneless ribeye steak, etc.)

Q = quantity purchased/consumed (lbs) of a particular cut of beef

P = price (\$/lb) of a particular cut of beef

α = intercept

β_1 = change in Q_{ij} given a relative change in P_{ij}

β_2 = change in Q_{ij} given a relative change in P_{ij}^2

where $\varepsilon = \{\beta_1 + 2\beta_2(\bar{P})\} \times \frac{\bar{P}}{\bar{Q}}$ for the quadratic model.

4.3.2.2. Assumptions underlying the Estimation Techniques

According to Gujarati (1988), the classical normal linear regression assumes that every u_i is normally distributed with

$$u_i \sim N(0, \sigma^2)$$

Using SAS, the non-parametric Kolmogorov-Smirnov test was performed on all the data to test for the normality assumption. The test was performed at the $\alpha = 0.05$ level of significance. The price and quantity data (including the transformed data) for all the stores and meat cuts met the requirements for normality. The residuals generated with all the models were also normally distributed. These non-parametric tests are probably neither very powerful nor very effective. It is well known that these tests generally have less power the lower the number of observations with n being 13 in this case. (Nevertheless, the tests were conducted for the sake of completeness). For this reason, the two-store data for each beef cut were combined thereby increasing the number of observations to 26. The Kolmogorov-Smirnov test was performed again on all the data at the $\alpha = 0.05$ level of significance. The price and quantity data for all the meat cuts, as well as the residuals generated by the models, all met the requirements for normality.

In addition to the normality assumption, five other assumptions, that are valid to the interpretation of the regression estimates, underlie the linear regression model. These assumptions are

1. Zero mean value of u_i – all the factors not explicitly included in the model are incorporated in u_i and do not affect the mean value of Q .
2. Zero autocorrelation between u 's – i.e. given P_i , the deviations of any two Q -values from their mean value should not exhibit any systematic patterns. The Durbin-Watson d test, which is based on the estimated residuals computed in the regression analysis, was used to test for serial correlation. The data for all the cuts except Select boneless top round steak was tested for autocorrelation. No evidence of serial autocorrelation was found except in the monthly simple average price data of Select boneless ribeye steak and monthly quantity-weighted price data of select porterhouse steak for the log-linear models in Store Two, and the monthly simple average price data of Select porterhouse steak for the log-linear model in Store One.
3. Homoscedasticity – to satisfy this assumption, the estimated squared residuals, e_i^2 , were plotted against the predicted Q_i 's to see if they exhibit any systematic patterns. No such patterns were detected between the variables in the log-linear and quadratic models.
4. Zero covariance between u_i and P_i – this assumption is met as P is non-random.
5. The regression model is correctly specified – given the purpose of the data analysis and the retail meat price data that was available, the models are considered to be specified correctly.

A further assumption is that the weekly supply of beef in these stores is perfectly elastic. The stores are assumed to have the ability to supply any amount of meat that they choose. Supply is therefore not a constraint on the pricing process and the huge variation in weekly quantities at different prices supports this assumption. A final assumption made in these models is that consumer income, and tastes and preferences are not a factor

constraining the quantity of meat purchased on a weekly basis since the time period was too short for major changes in these demand shifters.

4.4. Results and Discussion of the Empirical Data Analysis

4.4.1. Simple Average and Quantity Weighted Price Series

The computed simple average and quantity-weighted price series consisting of 13 monthly price observations are provided in Appendix C. For both stores across all the meat cuts, the monthly quantity-weighted price observations are usually significantly lower than the corresponding monthly simple average prices. The plots of monthly simple average and quantity-weighted prices for each meat cut on the same graph show this phenomenon more clearly. Figure 4.21 demonstrates a typical pattern with both types of prices for Store One, Select boneless ribeye steak, and show that the monthly quantity-weighted prices are lower than the corresponding monthly simple average prices. This pattern is present across all the other cuts. (Plots in Appendix D). Where exceptions occur, the simple average and quantity-weighted prices are either equal,⁶ or the quantity-weighted price is higher by no more than a couple of cents, which can be attributed to a lack of precision in price reporting (such as \$4.00 vs. \$4.02, etc.).

⁶ In the instances where the monthly simple average and quantity-weighted price are equal, it is because both average prices are based on four consecutive equal weekly price observations and quantity weighting does not, therefore, change the average price.

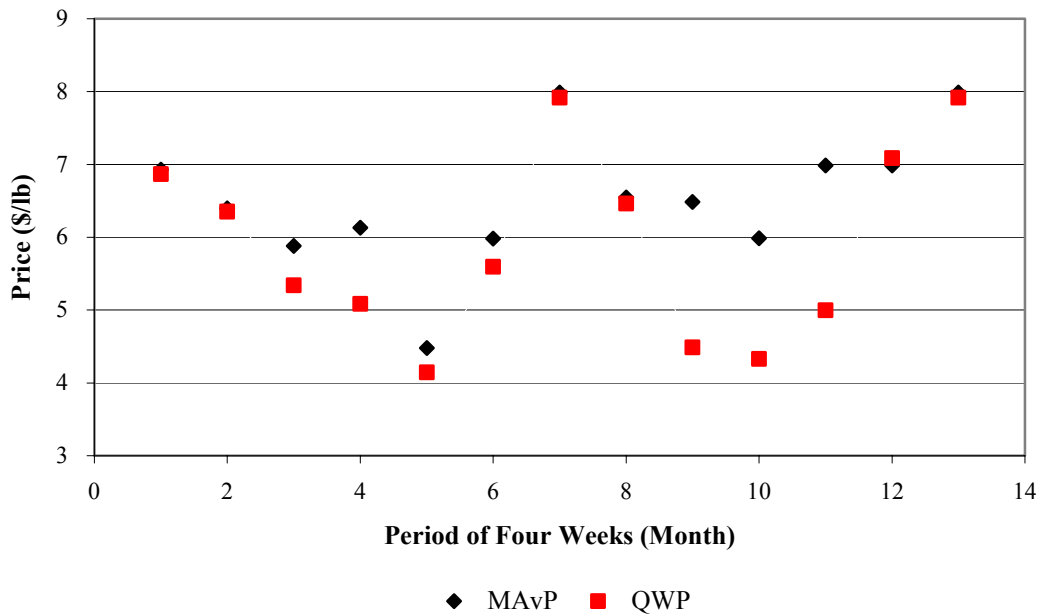


Figure 4.21. Monthly Simple Average (MAvP) and Quantity-weighted (QWP) Prices for Select Boneless Ribeye Steak in Store One for 13 Four-week Periods from 09/10/2000 to 09/02/2001.

Table 4.1 summarizes the averages⁷ and variances of the simple average and quantity-weighted price series for Stores One and Two for all meat cuts. In all the categories, except Store Two for boneless top round steak, the average of the quantity-weighted price series is always significantly⁸ lower than the average obtained from the simple average price series.⁹ For all meat cuts in both stores, except for porterhouse steak and Store Two data of top round steak, quantity-weighted price data results in a higher sample variance.¹⁰ Unfortunately, no other explanation other than the nature of the cut data can

⁷ This average is the figure obtained by simply computing the average, i.e., dividing the sum of the monthly price observations by the total number of observations (n), which is 13.

⁸ The t-test (two-sample assuming unequal variances) was used to test for differences between the means of the Quantity-Weighted and Simple Average price series, with the hypothesized mean difference being zero under the null hypothesis. The test was performed at the $\alpha = 0.05$ level of significance and $df = 12$. The null hypothesis was rejected when $|t\text{-Stat}| > |t\text{-critical}|$.

⁹ Once again the deviation associated with boneless top round steak is because the data for top round steak are not well behaved and are characterized by unexplained inconsistencies that one would not expect to be associated with a good of this nature.

¹⁰ The F-test was used to test for differences in the variances of the Quantity-Weighted and Simple Average price series, with equal variances being hypothesized under the null hypothesis. The test was performed at $\alpha = 0.05$ with $df = 12$. The null hypothesis was rejected when the F-value exceeded the critical F.

account for the exceptions noted in the outcomes of the variances for porterhouse steak and Store Two data of top round steak.

Table 4.1. Means and Variances for the Monthly Simple Average Price Series and Monthly Quantity-Weighted Price Series Data

Retail Beef Cut	Data							
	Simple Average Prices		Quantity- Weighted Prices		Simple Average Prices		Quantity- Weighted Prices	
	Store 1				Store 2			
	Mean	Var.	Mean	Var.	Mean	Var.	Mean	Var.
Select Boneless Ribeye Steak	6.52	(0.85)	5.90	(1.76)	6.55	(0.98)	6.08	(1.76)
Boneless Top Loin Steak	6.31	(0.58)	5.75	(1.43)	6.26	(0.53)	5.71	(1.22)
Select Boneless Top Round Steak	4.68	(0.10)	4.61	(0.14)	4.69	(0.10)	4.71	(0.09)
Select Porterhouse Steak	5.21	(0.59)	4.43	(0.19)	5.27	(0.59)	4.42	(0.18)
Ground Beef (75% Lean)	1.97	(0.09)	1.83	(0.20)	1.97	(0.11)	1.86	(0.20)

Notes: Figures in parentheses are the Variances (Var.).

4.4.2. A Comparison of the Models fitted to the Data

Each of the three models was fitted to the simple average price series and the quantity-weighted price series, by turn, for Store One and Store Two across all five cuts of meat.

1. Linear Model

The adjusted R^2 values obtained from fitting the linear models to the monthly simple average price series and the monthly quantity-weighted price series can be seen in Table 4.2. Looking at the associated t-statistics for the linear model (Table 4.3), the price coefficients for the simple average price model (MoAvP) and the quantity-weighted price model (QWP) are significant (i.e. $|t| > 2$) across all meat cuts. The only exceptions where the price coefficients are not significant are for porterhouse steak in the simple average price model, and both the simple average price and quantity-weighted price models for top round steak. However, the absolute values of the t-statistics are higher than the corresponding t-statistics obtained with the simple average model for all meat classes. In the case of Porterhouse steak, the improvement in the t-values is such that the coefficient on QWP actually becomes significant.

2. Log-linear Model

The adjusted R^2 values for both the log models, i.e. the log model fitted to the simple average price series and the log model fitted to the quantity-weighted price series, for the respective meat cuts are summarized in Table 4.2. The adjusted R^2 values for the log models fitted to the simple average price data are rather low for ribeye steak, porterhouse steak, and top round steak. On the other hand, the models fitted to the ground beef and top loin steak data have much higher adjusted R^2 values. The t-statistics (Table 4.3) for the simple average price and quantity-weighted price log models display the same characteristics as the corresponding t-statistics obtained with the linear models. The coefficients $\ln\text{MoAvP}$ and $\ln\text{QWP}$ are significant ($|t| > 2$) in all meat classes, barring top round steak, and the coefficient $\ln\text{MoAvP}$ for porterhouse steak. Fitting the log model to the quantity-weighted price series also resulted in improvements in the t-values. For porterhouse steak, the improvements resulted in significant t-values.

Table 4.2. Adjusted R² Values of Three Models Fitted to Monthly Simple Average Price and Monthly Quantity-Weighted Data by Store for Five Cuts of Beef.

Model	Beef Cuts									
	Select Boneless Ribeye Steak		Select Boneless Top Loin Steak		Select Porterhouse Steak		Select Boneless Top Round Steak		Ground Beef (75% Lean)	
	Store One	Store Two	Store One	Store Two	Store One	Store Two	Store One	Store Two	Store One	Store Two
<i>Linear</i>										
SAP [†] Series	0.287	0.290	0.541	0.456	0.190	0.173	0.028	-0.090	0.602	0.594
QWP [‡] Series	0.649	0.752	0.763	0.587	0.239	0.221	-0.038	-0.090	0.745	0.613
<i>Log-linear</i>										
SAP Series	0.251	0.253	0.668	0.525	0.142	0.071	0.025	-0.090	0.585	0.627
QWP Series	0.708	0.748	0.844	0.625	0.335	0.317	-0.030	-0.090	0.748	0.664
<i>Quadratic</i>										
SAP Series	0.250	0.219	0.497	0.412	0.459	0.420	-0.036	0.227	0.679	0.647
QWP Series	0.912	0.871	0.812	0.546	0.232	0.221	-0.112	0.195	0.817	0.635

[†]SAP refers to the price series consisting of monthly simple average prices.

[‡]QWP refers to the price series consisting of monthly quantity weighted prices.

3. The Quadratic Model

The adjusted R^2 values of the quadratic model for all meat cuts by store can be seen in Table 4.2. For all the cuts of beef other than top round steak, the quadratic model fitted to the simple average price data exhibited relatively high R^2 values, with ground beef located at the upper end of the range and ribeye steak at the lower end.

An examination of the t-statistics for the quadratic model reveals only a few cases occur where the coefficients are actually significant. For the simple average price data, the coefficient MoAvP only had significant t-values for Store One and Store Two data for porterhouse steak and ground beef. For the coefficient MoAvP², the only cut category in which the absolute t-values exceeds two for the data from both stores is porterhouse steak. The coefficients QWP and QWP² associated with the quadratic models fitted to quantity-weighted prices are significant across Store One and Two data for boneless ribeye steak, Store Two data for top round steak, and Store One data for ground beef. The only other occasion where the test for significance is satisfied is in the instance of the coefficient QWP for Store One data of top loin steak. The results of the t-statistics for the quadratic model are given in Table 4.3.

Table 4.3. T-statistics Associated with Coefficients on Price of Three Models Fitted to Data by Store for Five Cuts of Beef.

Model	Beef Cuts									
	Select Boneless Ribeye Steak		Select Boneless Top Loin Steak		Select Porterhouse Steak		Select Boneless Top Round Steak		Ground Beef (75% Lean)	
	Store One	Store Two	Store One	Store Two	Store One	Store Two	Store One	Store Two	Store One	Store Two
<i>Linear</i>										
SAP [†] Series										
MoAvP	-2.416	-2.427	-3.889	-3.323	-1.953	-1.876	1.158	-0.107	-4.375	-4.307
QWP [‡] Series										
QWP	-4.811	-6.118	-6.291	-4.248	-2.183	-2.010	0.747	0.068	-6.002	-4.476
<i>Log-linear</i>										
SAP Series										
lnMoAvP	-2.239	-2.249	-5.017	-3.776	-1.727	-1.386	1.142	-0.096	-4.233	-4.600
QWP Series										
lnQWP	-5.481	-6.045	-8.116	-4.580	-2.653	-2.565	0.806	0.076	-6.055	-4.975
<i>Quadratic</i>										
SAP Series										
MoAvP	-0.915	-0.196	-0.452	0.206	-2.761	-2.587	-0.526	-2.351	-2.445	-2.093
(MoAvP) ²	0.673	-0.019	0.214	-0.427	2.544	2.380	0.569	2.348	1.910	1.633
QWP Series										
QWP	-6.655	-4.037	-2.533	-0.403	-1.018	-1.078	-0.487	-2.209	-3.172	-1.779
(QWP) ²	5.816	3.333	1.969	0.070	0.948	1.001	0.520	2.212	2.307	1.290

[†]SAP refers to the price series consisting of monthly simple average prices.

[‡]QWP refers to the price series consisting of monthly quantity weighted prices.

4.4.3. A Review and Examination of the Values of the Own-Price Elasticity as Generated by the Models

Table 4.4 summarizes the own-price elasticities calculated using the linear, double log (log-linear), and quadratic models for each of the stores for all five beef cuts. The elasticities were calculated, in turn, first from the results of the models generated with simple average price series data, then from the results of the models generated with the quantity-weighted price series data as input. The reason for doing so was so that the elasticities derived from the simple average price series data and the quantity-weighted price series data could be compared by store within cuts and the impacts of quantity weighting upon the size of the elasticity parameter can be quantified.

The own-price elasticities for a particular store within a particular meat class, as generated using either simple average price data or quantity-weighted price data, are almost the same for all three models (Table 4.4). The generated elasticities are all very elastic (well above one in absolute value), and the only cut for which the value of the own-price elasticity sometimes falls below one, (indicating inelastic demand) is top round steak. The very high values obtained for the elasticities are partly due to the models having as their input only the price data for beef. No income or substitute meat (pork and chicken) store price data were available to include in the modeling exercises; therefore, the models, as they stand, capture only the effect of one price on the quantity of a cut of beef purchased. For this reason the value of the own-price elasticities are somewhat inflated.¹¹

With the exception of top round steak, the own-price elasticities for the four other beef cuts exhibit the correct sign: they are all negative, denoting the negative relationship between price and quantity. The discussion in Chapter I and the discussion of the survey

¹¹ When dealing with weekly observations, arguably income changes would have a negligible impact on the quantity response to a price change. But the impact of other meats cannot be dismissed, though expectations would be that pork or chicken prices would, if they change at all on a week to week basis, change in the same direction as the beef prices to keep the meat case “competitive.” To the extent that this is the case, the unmeasured impact of changes in substitute meats is captured in the price-quantity relationships in beef. This is different, of course, from including other prices in the model so that the price coefficient on beef is measured with “other meat prices held constant at their means.”

results suggested that the introduction of quantity weighting might lower the own-price elasticity, i.e. the own-price elasticity should become less negative, or alternatively, smaller in absolute terms because the mean price will be lower. This is indeed the case for the own-price elasticity of top loin steak and ground beef (75% lean). For porterhouse steak and ribeye steak, quantity weighting has the effect of increasing (making more elastic) the own-price elasticity. But in the case of ribeye steak, this increase is so small that it can be considered to be unchanged. The increases in porterhouse steak, on the other hand, are rather large and significant in both statistical and economical contexts. Nevertheless, the general conclusion that can be drawn from the changes in the own-price elasticity when going from simple average to quantity-weighted price data is that any expectation that the own-price elasticity will be lower is satisfied only about 50% of the time. The $\Delta Q/\Delta P$ response parameter does in fact appear to change (increases) with quantity-weighted prices to offset the reduction in price (or \bar{P}) at constant quantity (or \bar{Q}). It will be interesting to see what would happen to this percentage when substitute meat price and income data can also be included in the models and the aberrations noted in the data used can be explained.

Table 4.4. Own-Price Elasticities Generated from Three Models Fitted to Store Data for Five Cuts of Beef

Model	Beef Cuts									
	Select Boneless Ribeye Steak		Select Boneless Top Loin Steak		Select Porterhouse Steak		Select Boneless Top Round Steak		Ground Beef (75% Lean)	
	Store One	Store Two	Store One	Store Two	Store One	Store Two	Store One	Store Two	Store One	Store Two
	Own-price Elasticity									
<i>Linear</i>										
SAP [†]	-3.7730	-3.3665	-5.2068	-4.2482	-2.0816	-2.1049	1.1766	-0.1266	-2.2807	-1.6195
QWP [‡]	-3.3280	-3.4829	-3.5109	-2.8358	-3.3845	-3.5127	0.6515	0.0851	-1.5761	-1.1496
<i>Log-linear</i>										
SAP	-3.6604	-3.6162	-5.3856	-5.1018	-1.8479	-1.5691	1.5617	-0.1161	-2.0626	-1.4922
QWP	-3.6992	-4.0642	-3.3896	-3.2687	-3.7159	-3.8480	0.9426	0.0988	-1.3780	-1.0425
<i>Quadratic</i>										
SAP	-3.6186	-3.3733	-5.1331	-4.2885	-3.2673	-2.9476	1.5081	1.6941	-2.2774	-1.5742
QWP	-3.9747	-3.5930	-3.2093	-2.8343	-4.4958	-4.6473	0.8610	1.9958	-1.4441	-1.0802

[†]SAP refers to the prices series consisting of monthly simple average prices.

[‡]QWP refers to the price series consisting of monthly quantity-weighted prices.