Retail Demand for Whole vs. Low-Fat Milk: New Perspectives on Loss Leader Pricing

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Introduction

The adoption of scanner equipment by retail food companies over the past decade has revolutionized market analysis. In particular, retail scanner data have become a more common source of information for demand analysis. One principal advantage of scanner data is that they are rich in terms of product-specific information, allowing for demand analysis of product groups on a disaggregate level. In addition, the use of scanner data permits the focus of analysis on a shorter time period than other sources of data. Indeed, scanner data hold great promise for developing insights into store level performance.

This study seeks to gain new insights into a much investigated food product (milk) through the use of an individual retail company's scanner data. In the process, a meaningful analysis of promotional activities may be provided for this individual firm. Store specific elasticities may be useful for evaluating a firm's pricing strategy.

A basic knowledge of the price responsiveness of products used in promotional activities is important because it allows food retailers to set prices that maximize the benefits of the promotion. Additionally, this knowledge could be used by retailers to more accurately forecast sales of items featured in a price promotion, allowing for optimal ordering and inventory control by individual retails stores

Loss Leaders

Retailers expend significant resources so as to convince consumers to shop their stores. Sales promotion activities comprise a wide variety of short-term, tactical tools designed to generate an immediate market response. Such tactics include: radio announcements, television spots, frequent shopper cards, and weekly feature advertisements (fliers distributed through the mail or as newspaper inserts). A retailer's weekly advertisement typically features 100 to 150. These products, referred to as loss leaders, are priced at very low margins, sometimes negative, in an effort to generate traffic by diverting customers away from competing stores. Although an item priced this way might be sold at a loss, the supposition is that customers will purchase additional merchandise in other categories, leading to increased store sales and profitability.

However, the empirical evidence is mixed and suggests that retailer are not always successful in executing this strategy. Walters and MacKenzie (1988) conducted an empirical analysis of loss leaders and found that most loss leader promotions had no effect on store profit, but those that did affect profit did so by increasing store traffic. These results are somewhat at odds with the findings of Kumar and Leone (1988). Looking at diaper sales in 10 stores, their results indicated that the display, featuring, and price promotion strategies used by stores can result in increased sales for the brand within the store. Part of the increase is due to brand substitution within the store, primarily as a result of the price promotion, and some of the increase is attributable to consumers' substitution of stores in order to buy the product being promoted.

The practice of loss leader pricing also creates an overall low price image for the store and creates less disturbance (i.e. price wars among competition), than do general price cuts. Dreze (1995) investigated the timing of promotions and items included in those promotions for competing grocery chains. He showed that for some products retailers use loss leaders to protect their market share, but for other products it is in the best interest of retailers to avoid direct competition and encourage cross shopping in order to maintain a promotional pricing strategy.

A typical grocery store may carry upwards of 10,000 items, making consumers unfamiliar with the majority of prices. Therefore, leader prices are typically associated with high-frequency, high-traffic items. These include items that are on the daily menu, (e.g. meat) or are subject to repeat purchases (e.g. laundry detergent). Milk is a classic example of a loss leader for various reasons: it is an important item in many consumers' grocery budgets, it is perishable so it must be replaced often, and its perishability implies that the retailer will not sacrifice many sales in the next period when the price returns to its standard mark-up.

Demand for Milk

Analyses of milk are abundant in the extant literature. For the most part, these traditional demand analyses have been conducted with only a limited degree of disaggregation (Heien and Wessels, Boehm and Babb). However, some studies have disaggregated the products for analysis, generally on the basis of fat content.

Jensen (1995) studied the effects of nutrition information and household socioeconomic characteristics on market participation and amounts purchased of whole fat and low fat milk in the South. Results suggested promotion of milk purchases on the basis of nutritional benefits through health professionals and product packaging are useful tools for the dairy industry to attract market participation. Gould (1995) estimated a three equation demand system for fluid milk that varies by fat content. This study looked at milk purchased for at-home consumption over a twelve month period and included effects of household demographics (income, ethnicity, food stamps, compostition, region, seasonality, adult equivalents, and household size) producing own and cross price elasticities for whole, 2% and reduced fat milks. The study showed household demand to be inelastic for all types of milk. Kaiser and Reberte (1996) looked at the impacts of advertising on per capita sales response for whole, low-fat, and skim in New York. The results indicated that the long-term advertising elasticities were 0.16, 0.19 and 0.18 for whole, low-fat, and skim milk products, respectively.

However, an individual retailer typically observes item sales and not individual demand. Therefore elasticities presented in this analysis may not adhere to a priori expectations based on previous work. Further, although other studies have disaggregated the products, they also focused on other levels of the market. In comparison, this analysis will be able to draw implications for retail practices.

Data

This analysis utilizes weekly scanner data capturing the fluid milk sales of a prominent grocery retail chain in New York State. Senior management from this retail chain provided data from three stores selected as being representative of the chain as a whole. The three selected stores operate within the same MSA. The data include prices and quantities (measured in gallons) sold for over 30 universal product codes (UPCs) corresponding to fluid milk products. Individual UPCs represent products that vary by fat content, brand, and package size.

A visual inspection of the data reveals that the majority of milk sales are accounted for by gallon-size packages of store brand milk (figure 1). Promotional periods are characterized by spikes in the sales of store brand gallons and corresponding valleys in the sales of all other milk packages. Within the sales of store brand gallons, we see that individual milk types exhibit different sales levels, both overall, and in response to price promotions (figure 2).

To better manage the problem, the data are aggregated according to fat content. First, the data are aggregated into four groups defined by fat content — whole, 2%, 1%, and skim. Second, the data are aggregated into two brand groups — private label (store brand) and all other brands. Finally, the data are aggregated into two groups that account for package size — gallons, and all other sizes (half-gallons, quarts, and pints). In addition, the data are augmented by a weekly count of customer transactions for each of the three stores in the analysis. The data are aggregated across all three stores. Descriptive statistics for these variables are exhibited in table 1.

The data cover 61 weeks from September 1, 1996 through October 26, 1997. During this period, the retailer featured store-brand milk in nine separate price promotions. The advertising of milk promotions is accomplished through the use of the retailer's weekly newspaper insert. The size and position of these advertisements are constant, and feature only gallon-size packages of store-brand milk. Furthermore, the retailer generally sets one promotional price for all gallon packages of store-brand milk, regardless of fat content.

Although this analysis is based on weekly store-level data, we present a profile of the surrounding households in order to provide insight into the associated sales patterns. Households located within the surrounding zip codes are predominantly white, urban families (table 2). Forty-two percent of these households earn between $15,000 and $39,999 with another 32% earning between $40,000 and $74,999. From table 2 we also see that the majority of residents are between the ages of 25 and 54.

Methodology

The retail demand for various fluid milk products, and the potential effects of promotional activities, can be characterized by

$$q_i = f_i(p_1, p_2, \ldots, p_n, a_1, a_2, \ldots, a_m) \qquad \textbf{(1)}$$

where the *q*s represent the dependent quantity variables, *p*s represent the retailer's price offer, and the *a*s represent the retailer's non-price offer (Holdren). Non-price variables could include such factors as advertising, promotional activities, store cleanliness, customer service, and the number of facings (shelf space) given the product. A conceptual framework of this type has been used successfully in other analyses of retail scanner data (Capps; Capps and Nayga; Capps and Lambregts).

This analysis will concentrate on the demand for gallon-size packages of store brand milk for various reasons. First, these products constitute the majority of this retailer's fluid milk sales. In addition, this retailer's promotional pricing of milk exclusively involves gallon-size packages of store brand milk. Initial analyses involving other size/brand combinations were met with empirical difficulties. In this light, the dependent variables in (1) are gallons of whole, 2%, 1%, and skim store brand milk per 1,000 customer transactions. Weighted average prices are generated for these and competing milk products (brand name gallons, brand name other, and store brand other) to account for the price offering in (1). However, variables describing the retailer's non-price offer are not included in the analysis. In general, data on these variables were not available. In the case of advertising in the weekly circular, ads for milk were invariant with respect to size, placement, and product. Therefore, the effects of the milk promotion are captured only by prices. The resulting demand equations incorporate the following variables:

q_{whole}	gallons of store brand whole milk
$q_{2\%}$	gallons of store brand 2% milk
$q_{1\%}$	gallons of store brand 1% milk
q_{skim}	gallons of store brand skim milk
$p_{whole,i,j}$	price of whole milk
$p_{2\%,i,j}$	price of 2% milk
$p_{1\%,i,j}$	price of 1% milk
$p_{skim,i,j}$	price of skim milk

where

i = gallon size (g), other size (o)

j = store brand (s), other brand (b)

Thus, the system of demand equations (suppressing the time subscript) is specified as:

$$\begin{aligned}
\ln q_{whole} &= \beta_{10} + \beta_{11} \ln p_{whole,g,s} + \beta_{12} \ln p_{whole,g,b} + \beta_{13} \ln p_{whole,o,s} + \beta_{14} \ln p_{whole,o,b} + e_{whole} \\
\ln q_{2\%} &= \beta_{20} + \beta_{21} \ln p_{2\%,g,s} + \beta_{22} \ln p_{2\%,g,b} + \beta_{23} \ln p_{2\%,o,s} + \beta_{24} \ln p_{2\%,o,b} + e_{2\%} \\
\ln q_{1\%} &= \beta_{30} + \beta_{31} \ln p_{1\%,g,s} + \beta_{32} \ln p_{1\%,g,b} + \beta_{33} \ln p_{1\%,o,s} + \beta_{34} \ln p_{1\%,o,b} + e_{1\%} \\
\ln q_{skim} &= \beta_{40} + \beta_{41} \ln p_{skim,g,s} + \beta_{42} \ln p_{skim,g,b} + \beta_{43} \ln p_{skim,o,s} + \beta_{44} \ln p_{skim,o,b} + e_{skim}
\end{aligned} \qquad \textbf{(2)}$$

It is reasonable to expect that random exogenous factors could impact the demand of milk products. These factors could include competition from other stores, general economic activity, or other omitted factors like weather, holidays, and other promotional activities within the store (Eastwood, Gray, and Brooker). In this light, estimation of (2) is accomplished by means of a seemingly unrelated regression (SUR) or joint generalized least squares (JGLS) technique. The SUR is appealing in that it accounts for contemporaneous correlation in the disturbances, while allowing for a different coefficient vector for each demand equation. Also, because the right-hand-side variables differ across equations, the SUR may provide gains in estimation efficiency over the ordinary least squares procedure (Judge et al).

Empirical Results

Parameter estimates and associated *t*-statistics resulting from the SUR are presented in table 3. R^2 for the system of equations is 0.94. For the individual equations, the coefficient of multiple determination takes values between 0.55 and 0.84. Due to the log-log specification of the demand equations, elasticities are conveniently obtained from parameter estimates. In each equation, the own-price elasticity is negative and statistically significant at the 0.05 level of significance. Also, in each equation, the cross-price elasticities for sales of gallon-size packages of other brand milk and other-size packages of store brand milk are positive and statistically significant at the 0.10 level of significance. Contrary to expectations, the cross-price elasticity for other-size packages of other brand milk (a minimal portion of store sales) is negative in each milk type equation. However, this elasticity is significantly different from zero (at the 0.10 level of significance) in only the whole milk equation.

In general, the retail demand for reduced-fat (2%, 1%, and skim) milk products appears very price sensitive and elastic. Own-price elasticities for these products range from 1.8457 (1% milk) to –2.1964 (2% milk). The retail demand for whole milk, however, was less price sensitive. Own-price elasticity for whole milk was –0.8908, in the inelastic range.

Discussion

The results show that differences exist in the price responsiveness of milk products differing in the content of milk-fat. In particular, the changes in item movement this retailer observes in response to a price promotion are much more pronounced for reduced-fat milk types. Meanwhile the response observed for whole milk is inelastic. It should be pointed out that the elasticities presented here are sales elasticities — the percentage change in retail sales due to a one-percent change in the price of milk. Thus, these relationships are not adequately explained solely by traditional factors of demand. Rather, one must consider also other factors such as store patronage and shopping patterns.

In fact, industry experts would point out that it is unlikely that milk consumption has increased for the whole market as a result of the retail promotions. Instead, the retailer's sales increases most likely occur at the expense of either milk sales at other retail outlets, or milk sales in the following week. For this particular retailer, milk sales do not appear to decline in the weeks following a promotion. This suggests that this retailer has stolen sales from elsewhere in the market. Yet the unanswered question is why does a price promotion of milk have such a greater impact on reduced-fat milk types than on whole milk? The answer ultimately lies in the use of household panel data (obtainable through frequent shopper programs) specific to an individual retail chain. Thus, detailed sales could be associated to specific shoppers and stores.

This analysis also has more practical implications for a retail company seeking to improve the effectiveness of its promotional activities. These activities may involve the use of loss leader pricing, where the retail selling price is reduced to below normal levels in an effort to attract customers to the store. As stated previously, a successful loss leader will have a highly elastic sales response, potentially drawing more customers into the store.

The retail company in this analysis periodically uses milk as a loss leader, generally promoting all store brand gallons of milk at a single low price. However, our results show that setting prices according to fat content could enhance fluid milk promotions. In particular, low-fat milk products are more effective loss leaders, and therefore should be priced separately from whole milk. Furthermore, because of its inelastic sales response, one might suggest that the retailer should not reduce the price of whole milk at all. However, this is not a foregone conclusion for various reasons, which include: (a) the retailer may be seeking to promote a low price image for the store, (b) the retailer may want to be equitable to consumers who prefer whole milk, and (c) it may be that the promotion of whole milk still has a prominent impact on overall store sales.

In regards to (c), above, items with an elastic sales response are generally equated with items that generate store traffic, thereby having a positive impact on overall store sales. Thus, price promotions of whole milk are assumed to be ineffective at generating increased store sales. However, this is not a testable hypothesis, as the data for overall store sales is unavailable.

In conclusion, this analysis has utilized a neglected source of sales information, namely, the scanner data of a specific retailer. The benefits of using such data include the ability to examine products at a highly disaggregated level, and examine specific management practices. It has been shown that differences exist in the sales responses of various milk products. Further analysis would benefit from additional data on overall store sales, or on individual consumers through the use of frequent shopper data. With this additional information one could examine a promotion's ability to affect store sales, and provide insights into the source of increased item movement.

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Tables and Figures

Table 1. Descriptive Statistics of Weekly Scanner Data, (n=61 weeks).

	Mean	Standard Deviation	Minimum	Maximum
CUSTOMER COUNT (Transactions)	58,898	2,618.7	50,879	65,083
QUANTITIES				
Private Label Gallons		*Gallons/1,000 Transactions*		
Whole	28.75	5.01	21.47	42.81
2%	49.42	19.99	32.51	106.70
1%	20.25	6.80	13.40	41.20
Skim	26.76	9.75	18.09	55.35
Private Label ½ Gallons, Quarts, and Pints				
Whole	20.90	2.11	16.98	26.23
2%	28.29	3.30	21.99	36.00
1%	11.48	1.20	9.22	14.99
Skim	23.09	2.40	18.09	28.26
Other Brand Gallons				
Whole	3.26	0.98	1.03	5.02
2%	3.28	1.18	0.52	5.00
1%	2.48	0.94	0.45	3.97
Skim	3.08	1.17	0.31	5.00
Other Brand ½ Gallons, Quarts, and Pints				
Whole	0.84	0.12	0.60	1.18
2%	0.50	0.10	0.28	0.86
1%	0.22	0.07	0.04	0.39
Skim	0.35	0.11	0.11	0.70
AVERAGE WEIGHTED PRICES				
Private Label Gallons		*$/Gallon*		
Whole	2.42	0.29	1.78	2.79
2%	2.39	0.28	1.68	2.69
1%	2.39	0.28	1.68	2.69
Skim	2.39	0.28	1.68	2.69
Private Label ½ Gallons, Quarts, and Pints				
Whole	2.68	0.20	2.42	3.00
2%	2.67	0.20	2.41	2.99
1%	2.67	0.20	2.41	2.99
Skim	2.67	0.19	2.41	2.98
Other Brand Gallons				
Whole	2.46	0.10	2.27	2.68
2%	2.44	0.08	2.27	2.64
1%	2.41	0.07	2.26	2.57
Skim	2.36	0.07	2.25	2.49
Other Brand ½ Gallons, Quarts, and Pints				
Whole	3.03	0.09	2.79	3.22
2%	2.73	0.13	2.43	2.99
1%	2.54	0.14	2.36	2.78
Skim	2.55	0.15	2.36	2.82

Table 2. Demographic Profile of Surrounding Households[a].

	Number	Percent[b]
Households	19,645	
Family	13,342	68%
Non-Family	6,303	32%
Income		
Less Than $15,000	3,379	17%
$15,000 to $39,999	8,229	42%
$40,000 to $74,999	6,319	32%
$75,000 or more	1,718	9%
Persons	48,849	
Urban	46,232	95%
Rural	2,617	5%
Race		
White	46,388	95%
Black	1,513	3%
Native American	80	<1%
Asian	760	2%
Other	108	<1%
Ethnicity		
Hispanic	619	1%
Age		
1 to 17	10,682	22%
18 to 24	4,711	10%
25 to 54	20,900	43%
55 and above	12,556	26%

SOURCE: U.S. Census Bureau.

a. Includes households living within the same zip codes as the stores pertaining to this study.

b. May not total 100% due to rounding.

Table 3. Parameter Estimates from Seemingly Unrelated Regression.

		Equation			
Variable		Whole	2%	1%	Skim
Intercept		3.2297*[a]	3.2821*	2.4839*	2.7728*
		(8.19)[b]	(8.07)	(5.70)	(8.05)
Price of Whole Milk					
Gallon-size	Store brand	-0.8908*			
		(-7.70)			
Gallon-size	Other brand	1.1414*			
		(2.06)			
Other size	Store brand	0.6595*			
		(2.11)			
Other size	Other brand	-0.7034*			
		(-1.85)			
Price of 2% Milk					
Gallon-size	Store brand		-2.1964*		
			(-16.04)		
Gallon-size	Other brand		1.2189*		
			(2.21)		
Other size	Store brand		2.0070*		
			(6.79)		
Other size	Other brand		-0.5932		
			(-1.58)		
Price of 1% Milk					
Gallon-size	Store brand			-1.8457*	
				(-13.73)	
Gallon-size	Other brand			1.2083*	
				(1.77)	
Other size	Store brand			1.4138*	
				(1.88)	
Other size	Other brand			-0.3984	
				(-0.38)	
Price of Skim Milk					
Gallon-size	Store brand				-2.1622*
					(-18.79)
Gallon-size	Other brand				1.7341*
					(3.17)
Other size	Store brand				1.3835*
					(3.61)
Other size	Other brand				-0.5482
					(-1.18)
Diagnostics					
R^2		0.55	0.84	0.78	0.84
System R^2		0.94			

a. An asterisk (*) indicates significance at the 0.10 level.
b. *t*-statistics are reported in parentheses.

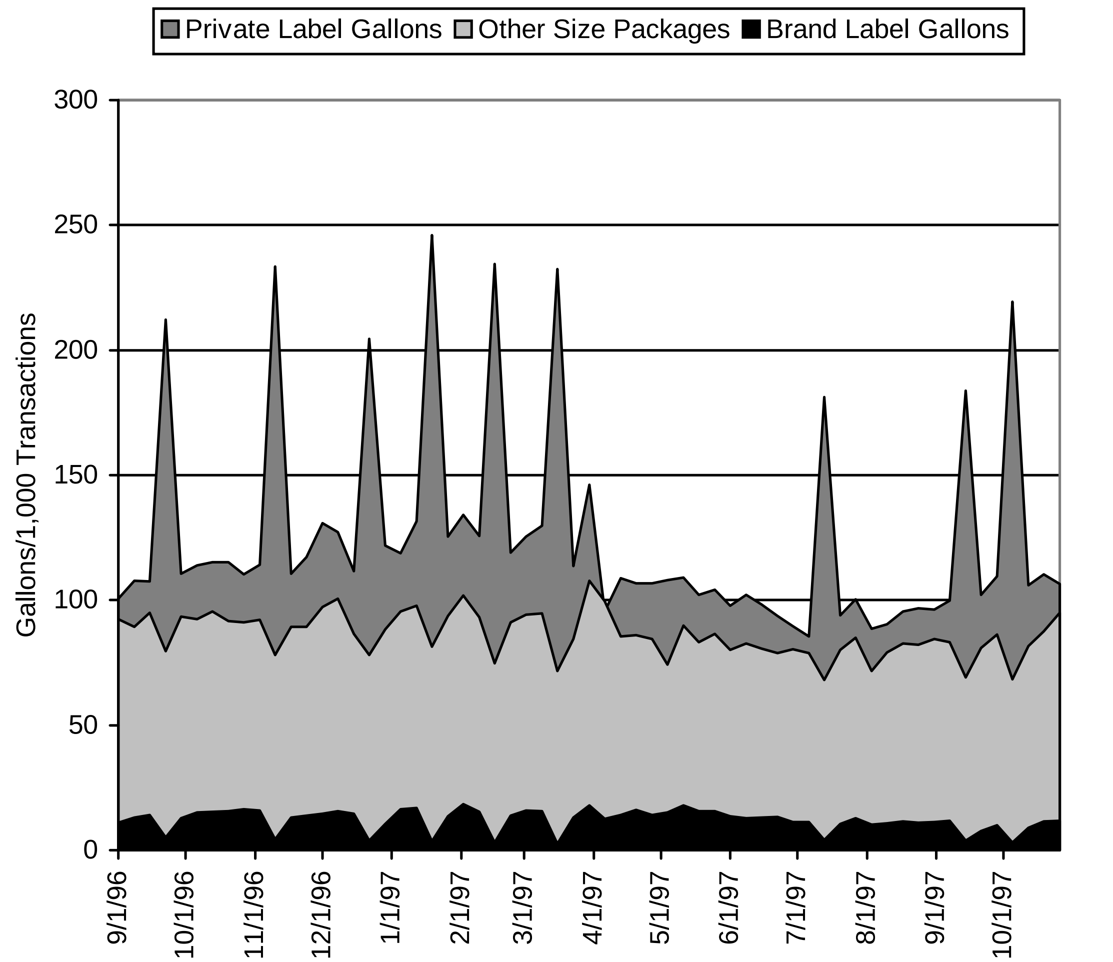

Figure 1. Individual retail sales of fluid milk by package type.

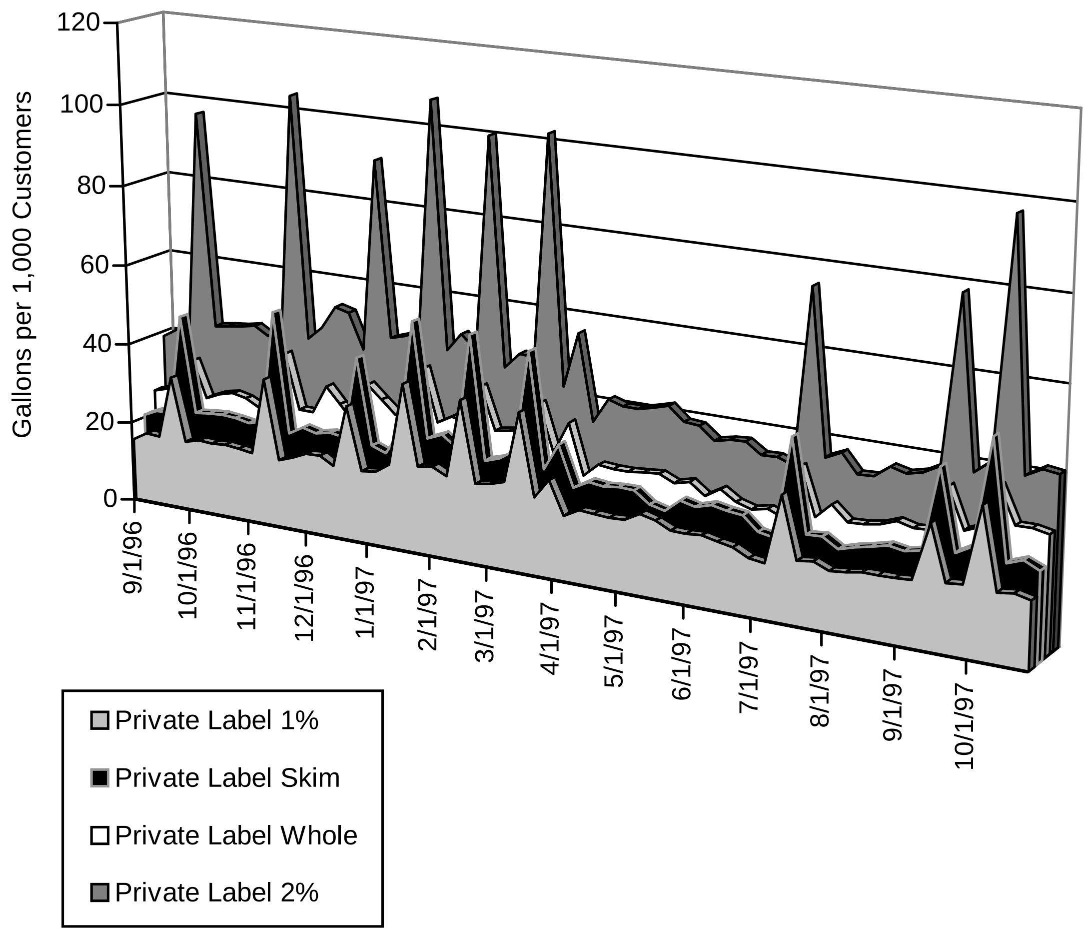

Figure 2. Retail sales of store brand gallon packages of milk by milk type.