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Supermarket competition during the price war: the case of Dallas-Fort Worth milk market

Abstract

This paper estimates the effect of a price war on fluid milk supermarket performance in Dallas-Fort Worth. The model is estimated with four-week-ending scanner data from the Dallas-Fort Worth milk market area at the supermarket level. First, a discrete choice model is used to estimate the demand for fluid milk at the brand and retail levels. The demand parameters are then used to estimate the price-cost margins before and during the price war under two pricing conduct scenarios: Bertrand and perfect collusive pricing. The results indicate that the Nash-Bertrand price behavior is preferred to the perfectly collusive pricing behavior. In addition, the price-cost margins dropped during the price war for the private label brands that actively participated in the price war. In fact, the Lerner index for these private label products was negative during the price war, consistent with the loss-leader behavior.

Keywords: price war, price-cost margins, milk, supermarkets, discrete choice.

Introduction

The issue of supermarket competition has received a great deal of attention in both the industrial organization and marketing literature. Unlike in the past, when supermarkets were treated as neutral pass-through between manufacturers and consumers, most of the recent literature in empirical industrial organization and marketing emphasizes the importance of the role played by retailers, either in setting prices consumers pay for their products or in providing other services (added value) in a single one-stop shopping location (Blumenthal and Cohen, 1998).

In addition, the increasing concentration in the U.S. supermarket industry raises concerns, especially among farmers and consumer groups, about the possibility of exercising market power in dealing with suppliers (buying power) and consumers (selling power). According to the United States Census Bureau and Trade Dimensions Marketing Guidebook, the top four retailers in the U.S. controlled approximately 18% of total sales in 1982, but they controlled 43% in 1999. Though the supermarket industry could be characterized as a monopolistic competition at the national level, the structure of this industry at the local or regional level is mainly oligopolistic (Slade, 1995; Richards, 2007).

Put in this context, the fluid milk price competition among Dallas-Fort Worth (hereafter DFW) supermarket chains offers an interesting case study. In fact, fluid milk consumers in this oligopolistic market have been benefiting from a price war among supermarket chains, which has at times lowered the price of milk to \$0.79/gallon. The fluid milk pricing conduct of DFW retailers during March 1996 through July 2000 can be decomposed in two different periods. During the first period (March 1996 to April 1999), retail milk prices fluctuated as a response to the variation of the farm price, with the response being immediate when the farm price increased and slow and lagging behind when the farm price decreased. During the second period (May 1999 to July 2000), the pricing conduct of the five supermarket chains degenerated into a price war that resulted in fluid milk selling for \$0.79/gallon in some stores, substantially below the farm price (see Figures 1 and 2). One question that comes to the researcher's and policy makers' minds concerns the level of competition prevailing in the DFW supermarket industry. Also the pricing strategies used by different players to gain market share in this particular market are important.

The objective of this paper is to estimate the effect of the price war on fluid milk supermarket performance by estimating the price-cost margins of the retailers in selling fluid milk, and how these margins vary with the price war.

The issue of measuring the degree of competition in the oligopolistic market has been the focus of many studies in empirical industrial organization. In this literature, there have been two documented approaches: the first is the conjectural variation approach, where the focus is on estimating a conduct parameter that informs on degree of competition of the market or industry analyzed, and that nests the perfect competition, perfect collusion, and Cournot/Bertrand models (e.g., Iwata, 1974; Gollop and Roberts 1979; Applebaum, 1982; and Liang, 1989)[1]. The second approach is the menu approach, where a number of models based on strategic games played by firms are estimated and compared to find which game offers the best fit to data at hand. This paper proceeds by adopting the menu approach, in which a horizontal Nash-Bertrand game is tested against a perfectly collusive pricing game.

[1] For a critique on conjectural variation approach, see Corts (1999).

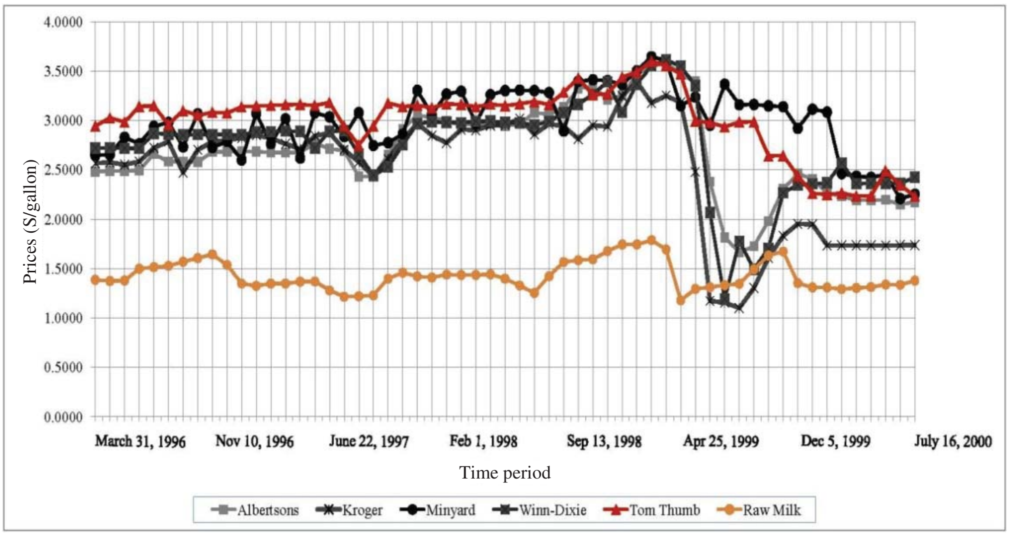

Fig. 1. Evolution of farm and retail milk prices for private label (March 1996-July 2000)

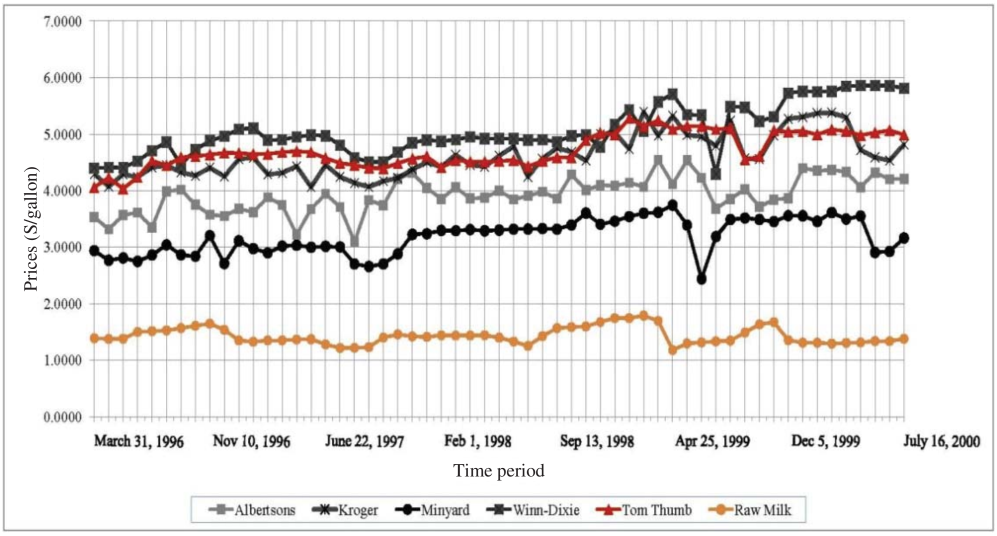

Fig. 2. Evolution of farm and retail milk prices for national brand (March 1996-July 2000)

The conduct and behavior of firms during price wars have been the subject of several studies. Schendel and Balestra (1969) argue that despite claims that price wars can be unprofitable to the industry, price wars may yield profits, at least to some participants. According to these authors, short-term profit motivation and entry deterrence are the main motivations for price wars. Porter (1983) tests switching from collusive to non-cooperative for firms in a cartel and rejects that the switch is attributable to exogenous shifts in demand and cost functions. Another example of price wars studies is the one by Rotenberg and Saloner (1986) in which the authors argue that price wars and price cutting practices are more likely to occur during high demand or booms.

In this paper, we approach the problem in the following way. First, we estimate a demand at brand and supermarket level using the whole data set. Using the demand parameters, we compute the brand/supermarket price-cost margins and the implied marginal cost for the period before the price war for the Nash-Bertrand and perfectly collusive pricing games. Second, assuming no shocks to cost, we forecast the marginal cost and recover the price-cost margins for the price war period. In doing so, we estimate the price-cost margins before the price war using the profit-maximization theory; we use an empirical approach to recover these margins during the price war period.

The rest of the paper is organized as follows. In section 1, we describe the DFW supermarket industry and the fluid milk market. The model developed for estimating the demand for fluid milk and the price-cost margins for each supermarket chain are presented in section 2. Section 3 presents the data used in the analysis, while the empirical results are presented in section 4. The final section draws the conclusions.

1. Dallas-Fort Worth supermarket industry and the fluid milk market

In Dallas-Fort Worth, the supermarket industry is dominated by five supermarket chains: Albertsons, Kroger, Minyard, Winn-Dixie and Tom Thumb, which control more than 71% of total grocery sales. In this market area, Albertsons supermarket chain leads the grocery market by controlling a market share of more than 28%, followed by Winn-Dixie, with 16.7%, Kroger, with 15.3%, Minyard, with 13 %, and Tom Thumb, with 12%[1]. In DFW, Albertsons supermarkets operated more than 62 stores in 1996, representing approximately 2.5 million square feet of space and more than $25 million of weekly grocery sales. By 2000, Albertsons supermarkets operated 82 stores, totaling more than 4.2 million square feet of space, which represents an increase of 69% over 1996. However, their weekly grocery sales decreased by 24% over 1996 and totaled approximately $20 million of weekly grocery sales.

Kroger is the top grocery retailer in the country and operates more than 2500 supermarkets in 31 states, with a wide variety of store formats. In 2000, Kroger operated 64 supermarket stores in DFW, totaling more than 3 million square feet of space, an increase of 29% over 1996, when Kroger operated 66 supermarket stores, totaling approximately 2.4 million square feet of space. As for Albertsons, the Kroger's weekly grocery sales decreased from more than $18.7 million in 1996 to approximately $13.3 million in 2000.

In 1996, Tom Thumb supermarket chain operated 48 stores, totaling more than 1.5 million square feet of space, and generating more than $16 million of weekly grocery sales. These figures increased to 57 stores in 2000, totaling approximately 2.6 million square feet of space and more than $18.8 million of weekly grocery sales.

Minyard supermarket chain operated 65 supermarkets in the DFW metropolitan area. The number of Minyard supermarket stores decreased from 48 in 1996 to 43 in 2000. However, the space controlled by Minyard increased from 1.1 million square feet in 1996 to 1.5 million square feet in 2000; while the weekly grocery sales dropped from $8.7 million in 1996 to $7.3 million in 2000.

The last retailer considered in this study is the Winn-Dixie supermarket chain. In DFW, Winn-Dixie operated 40 supermarket stores in 1996, representing 1.2 million square feet of space and yielding $8.85 million of weekly grocery sales. By 2000, Winn-Dixie operated 48 stores, totaling 2.1 million square feet of space and $8.3 million of weekly grocery sales.

The DFW fluid milk market is an interesting case study where the intervening supermarkets use the fluid milk pricing as a strategy to compete against each other and against the other retail formats. The fluid milk pricing conduct of the DFW retailers during March 1996 through June 2000 can be decomposed into two different periods. During the first period (March 1996 to April 1999), retail milk prices fluctuated as a response to the variation of the farm price, with the response being immediate when the farm price increased and slow and lagged when the farm price decreased. Using the four-weekly data from Information Resources Incorporated-Infoscan (IRI), the partial correlation coefficient between the farm price and the retail prices ranges from 0.47 (correlation between Tom Thumb fluid milk prices and the farm price) to 0.67 (correlation between Kroger fluid milk prices and the farm price). During the second period (May 1999 to June 2000), the pricing conduct of the five supermarkets degenerated into a price war. In May 1999, Kroger began dropping its fluid milk prices and the average milk price in Kroger's stores reached $1.29/gallon. Some competitors such as Albertsons and Winn-Dixie quickly followed it, setting their fluid milk prices at $0.79/gallon in some stores. The partial correlation coefficient between farm price and retail prices dropped significantly to almost zero (the correlation between the farm price and Winn-Dixie prices was 0.02).

During the price war, the pricing strategies of the five supermarket chains in DFW switched from non-competitive conduct where the spread between the retail price and the farm price was widening to a conduct where fluid milk was priced below its cost (GAO, 2001). The supermarket chains moved together to a great extent during the first period, as shown in Figures 1 and 2. The correlation coefficient of the retail milk prices for the five supermarkets ranges from 0.79 to 0.93, showing a strong correlation between retail prices in different supermarket chains. During the price war, the correlation coefficient of the retail milk prices for the DFW supermarkets dropped significantly and some of them were even negative, implying price movement in opposite directions. In addition, the supermarket chains used more their private label brands than the national brand during the price war (see Figures 1 and 2).

2. The model

2.1. Demand side. We assume that fluid milk is a differentiated product across supermarkets. This differentiation is the result of the differences between supermarket chains in many dimensions: one-stop shopping convenience, promotional activities, location, and the quality of the service offered to shop-

[1] The information contained in this section comes from the retailers' website and the Market Scope, a publication of Trade Dimensions. Also, the information pertains to the period of March 1996-July 2000.

pers. The consumer chooses a product from competing products in order to maximize utility, driven by the product characteristics. The consumer has also the possibility to shop for other products from outside the choice set (the outside option). The indirect utility of choosing a product j is given by

$$U_{ijt} = \zeta_j + x_{jt}\beta_i + \alpha_i p_{jt} + \varepsilon_{ijt}, \quad i = 1,..n, \quad j = 1,...J, \tag{1}$$

where ζ_j is the supermarket specific intercept, x_{jt} represents a vector of product characteristics for the brand j, at time t[1]. p_{jt} is the price of the brand j, and ε_{ijt} represents the distribution of consumer preferences about the unobserved product characteristics, with a density $f(\varepsilon)$. α_i is the price parameter, and β_i is a vector of product characteristics parameters. In what follows, the subscript t is dropped for ease of presentation.

Moreover, the parameters α_i and β_i are allowed to vary across consumers according to the following expressions:

$$\alpha_i = \alpha + \lambda D_i + \gamma v_i, \quad \beta_i = \beta + \varphi D_i + \rho v_i, \tag{2}$$

where D_i denotes a vector of observed consumer's characteristics (e.g., income, number of children, age,) with an empirical distribution $h(D)$; and v_i denotes the unobserved consumer's characteristics, assumed to follow a standard normal distribution $g(v)$. To complete the model and define the market, an outside good is included to give the consumer the option not to buy any of the J brands included in the choice set. The utility of the outside good is normalized to be constant over time and equal to zero. In addition, we make the usual assumption that consumers buy only one unit of the brand chosen.

The consumer chooses the brand that gives her the highest utility within the choice set. Aggregating over consumers in the market, the market share of the brand j corresponds to the probability the j^{th} brand is chosen. That is

$$s_j = \int I\{(D_i, v_i, \varepsilon_{ij}) : U_{ij} \geq U_{ik} \forall k = 0,1,...,J\} dH(D)dG(v)dF(\varepsilon). \tag{3}$$

Using the above equation, the price response of the market shares is:

$$\delta_{ij} = \frac{\partial s_j}{\partial p_k} = \begin{cases} \int \alpha_i (1 - s_{ij}) dH(D)dG(v)dF(\varepsilon) & for \quad j = k \\ -\int \alpha_i s_{ij} s_{ik} dH(D)dG(v)dF(\varepsilon) & otherwise \end{cases}, \tag{4}$$

where s_{ij} is the probability that consumer i chooses brand j. Assuming that the error terms, ε_{ij}, are distributed i.i.d. with an extreme value type I density, and using the empirical and standard normal distributions for the consumers observed and unobserved characteristics, respectively; we obtain the multinomial logit model with consumer heterogeneity.

2.2. Supply side. The DFW supermarket industry is characterized by a small number of firms each offering consumers a unique bundle of products-store combinations. Each retailer sells a national brand and a private label in the whole and reduced fat milk[2] categories. Starting with a horizontal Nash-Bertrand competition, consider then the case where a retailer chooses the fluid milk retail prices for his products to maximize his profits. The r^{th} retailer's problem is to maximize the profits given by[3]

$$\pi_r = \sum_{j=1}^{4} (p_j - c_j) s_j(p) M, \tag{5}$$

where p_j is the fluid milk retail price, c_j is the retailer's marginal cost, and s_j is the market share of brand j; p is a vector of retail prices at all supermarkets; and M is a measure of the market size, which includes sales of fluid milk in all supermarkets and the outside option. The first-order conditions are given by

$$s_j + \sum_k (p_k - c_k) \frac{\partial s_k}{\partial p_j} = 0, \quad j,k = 1,...,J. \tag{6}$$

Repeating the procedure for each retailer and stacking the solutions together in a matrix form, we obtain the retailers' equilibrium price-cost margins as a function of the demand parameters:

$$p - c = -(T.\times\delta)^{-1} s(p) \tag{7}$$

where c is a vector of marginal costs, δ is a matrix of first derivatives of the market share with respect to retail prices, given by equation (4). T is a matrix of zeros and ones, used as an artifice to express the equation in matrix form[4]. The $(T.\times\delta)$ is the element by element multiplication of the two matrices. Note

[1] We assume that the product characteristics do not change during the period of study.

[2] Reduced fat milk includes 1%, 2%, and skim milk.

[3] Each retailer is selling four milk products: private label whole milk, private label reduced fat milk, national brand whole milk, and national brand reduced fat milk.

[4] Some authors call T a matrix of ownership, with elements (j, k) equal 1 if the brands j and k are sold by the same retailer and 0, otherwise.

that the price-cost margins are a function of demand parameters; the estimation of the demand will allow recovering the price-cost margins and computing the Lerner index. In the case of perfectly collusive pricing, the price-cost margins are obtained using equation (8) with the matrix *T* full of ones.

Either, with Nash-Bertrand or collusive pricing behavior, the conduct of the retailers during the fluid milk price war in DFW market would imply negative price-cost margins because the retail prices in some supermarket chains were cut to levels below farm price. One explanation advanced to justify negative markups is the loss leader practice. The loss leader practice consists in setting prices for selected products at low levels in order to increase store traffic and sales on the other products with higher markups. However, this practice cannot explain the DFW supermarket pricing conduct for fluid milk for, at least, two reasons. First, the examination of historical fluid milk prices before the price war shows (see Figures 1 and 2) that for this product, the spread between farm price and retail prices is widening. Consequently, supermarkets were selling fluid milk at traditional profit margins. Second, there have been some market studies in the U.S. that evidenced the retailers' market power in selling fluid milk; see for example Sexton and Carman (2005) for the Seattle-Tacoma market and et al. (2005) for the Boston market.

To recover the price-cost margins during the price war we proceed as follows. We divide our data into two samples: one before the price war and one after. For the first sample, we use equations (8) and (9) to recover price-cost margins for Nash-Bertrand and collusive pricing games. Notice that, given the demand parameters, the price-cost margins are computed and the marginal costs are recovered[1]. Assuming a constant marginal cost, a common assumption in the industrial organization literature, we regress the recovered marginal cost on the input prices for the first sample, that is,

$$MC = c_0 + \sum_i c_i w_i, \qquad (8)$$

where *MC* is the recovered marginal cost, w_i is the price of the i^{th} input, and c_0 and c_i are parameters to be estimated. The above regression is then used to predict the marginal cost during the price war period. Finally, the price cost margins for the price war period are computed using the retail prices and the predicted marginal cost.

3. Data description and estimation issues

This study uses Information Resource Incorporated-Infosacan (IRI) data provided by the Food Marketing Policy Center at the University of Connecticut[2]. It includes 57 four-week-ending observations covering the period from March 1996 to July 2000 for five supermarket chains in the DFW metropolitan area. The five supermarket chains included are Albertsons, Kroger, Tom Thumb, Minyard, and Winn-Dixie. These supermarket chains control more than 73% of the fluid milk volume sales in the market. The IRI data consist of dollar sales, volume sales, and the retail prices obtained by dividing the dollar sales by the volume sales. Further, the retail prices were deflated by the consumer price index from the U.S. Bureau of Labor Statistics.

One of the important limitations of the IRI data is that it does not include Wal-Mart as well as mass merchandizers and convenient stores. This might raise question about the market definition and hence the validity of the results. However, for our market, the five supermarket chains sold approximately 74% of the total milk in DFW metropolitan area during the period of study (June 1996-July 2000). To our knowledge, most differentiated demand analyses do not cover the totality of the market. For instance, Villas-Boas IRI data covering the purchases of yogurt in just three retail stores in a Midwestern U.S. urban area with a combined market share of 34%. Moreover, several studies have used Dominick IRI data made available by the University of Chicago Booth School of Business (e.g., Dubé and Gupta, 2008; Levy et al., 2010; Pofahl and Richards, 2009; and Slotegraff and Pauwels, 2008)[3]. The data include one supermarket chain operating 94 stores in the Greater Chicago metropolitan area, with a market share of about 25%. We therefore, feel comfortable that the data at hand will produce valid results given that our market presents 74% of the total DFW milk purchase.

For each supermarket chain, the fluid milk is divided into two categories: reduced fat milk and whole milk. In each category, the analysis is conducted for the private label and the national brand. These results in four differentiated products sold in five differentiated supermarket chains. Two dummy variables were created to differentiate between the whole and the reduced fat milk, and the national brand and private label, respectively. In addition, four supermarket chain dummy variables were used to differentiate between supermarket chains. Also, given that the model takes into account the consumers' heterogeneity, the demographic data on household income and the number of children in the household were obtained as random draws from the Current Population Survey for DFW.

[1] Demand is estimated using the full sample.

[2] We thank Dr. R.W. Cotterill for allowing us to use the data.

[3] For a list of publications that used Dominick IRI data, visit http://research.chicagobooth.edu/marketing/databases/dominicks/papers.aspx.

The demand model presented above implies the need to use instrumental variables to account for the potential endogeneity of milk retail prices. This endogeneity comes from the fact that the retail prices depend on the supermarket characteristics, and any variation in those characteristics will induce a variation in retail prices. This study uses some cost data interacted with the brand dummies as instruments. The cost data include the farm milk price given by the Federal Milk Marketing Order (FMMO) announced class I price, the average retail wage in DFW market area ($/hour), a U.S. index for packaging materials from the website of the U.S. Bureau of Labor Statistics, the Moody's bond rate for 10 years as an opportunity cost for variable capital inputs obtained from Economagic website, and the price of electricity for industrial use in Texas obtained from the U.S. Department of Energy website. The average volume per unit sold, from the IRI database, was also included as a proxy for the amount of materials and added labor needed to supply a given volume of milk. To estimate equations (3) and (4), we follow the algorithm outlined in Nevo (2000). Table 1 gives descriptive statistics of the data used in the analysis.

Table 1. Descriptive statistics

Variables	Market share (%)				Price ($/gal)			
Brand-supermarket	Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max
Albertsons								
Reduced fat milk (Borden)	0.89	0.17	0.6	1.48	3.92	0.32	3.09	4.55
Reduced fat milk (private label)	13.58	1.69	11.06	16.7	2.69	0.45	1.66	3.59
Whole milk (Borden)	0.89	0.27	0.58	1.98	3.64	0.31	3.03	4.42
Whole milk (private label)	4.48	1.85	2.04	7.48	2.78	0.54	1.43	3.59
Kroger								
Reduced fat milk (Borden)	0.2	0.03	0.14	0.26	4.62	0.38	4.06	5.39
Reduced fat milk (private label)	12.6	0.75	11.37	15.36	2.51	0.59	1.1	3.39
Whole milk (Borden)	0.27	0.04	0.18	0.37	4.32	0.49	3.57	5.33
Whole milk (private label)	3.93	2.99	1.87	11.14	2.79	0.77	1.07	3.78
Minyard								
Reduced fat milk (Borden)	1.45	0.37	0.64	2.02	3.18	0.31	2.44	3.74
Reduced fat milk (private label)	1.9	0.35	1.12	2.8	2.99	0.33	2.21	3.64
Whole milk (Borden)	5.51	0.98	3.27	8.1	2.83	0.25	2.2	3.36
Whole milk (private label)	1.86	0.56	1.13	3.55	3.08	0.38	2.25	3.81
Winn-Dixie								
Reduced fat milk (Borden)	0.09	0.02	0.05	0.11	5.06	0.44	4.29	5.86
Reduced fat milk (private label)	3.73	0.38	2.85	4.39	2.75	0.48	1.18	3.61
Whole milk (Borden)	0.14	0.02	0.09	0.17	5.03	0.45	4.11	5.84
Whole milk (private label)	3.75	0.31	3.26	4.93	2.74	0.5	1.17	3.62
Tom Thumb								
Reduced fat milk (Borden)	0.62	0.08	0.47	0.88	4.71	0.3	4.03	5.28
Reduced fat milk (private label)	8.03	0.96	5.75	9.81	2.99	0.35	2.23	3.6
Whole milk (Borden)	0.33	0.06	0.24	0.51	4.5	0.38	3.66	5.06
Whole milk (private label)	2.75	0.47	2.01	3.68	2.89	0.39	2.07	3.59
Demographics								
Income ($)	70,574	4,672	320	301,363				
Number of children	0.6919	0.0375	0	6				
Inputs								
Raw milk ($/gal)	1.4289	0.1463	1.1782	1.7871				
Wage ($/hr.)	11.8462	0.3205	10.98	12.3				
Electricity (cent/kwh)	3.9103	0.3133	2.9	4.5				
Packaging (index)	116.4517	1.9062	113.2	120.2				
Interest rate (%)	5.9751	0.6428	4.53	6.91				

Given that all supply models are not nested, the non-nested test of Vuong (1989) is used to test between the Nash-Bertrand game and the perfectly collusive pricing game. The test of Vuong (1989) tests whether the competing models are equally close to the true data that generated the process or that one of them is closer. The test applies in the case the competing models are non-nested, overlapping or nested. Besides, the Vuong (1989) test does not require that either competing model be accurately specified under the null hypothesis.

Let G denotes the different competing models considered in the previous section. For each model, given the implied price-cost margins, we can estimate the marginal cost representing the sum of the production cost and the distribution cost. This marginal cost is given by

$$MC_j^G = p_j - PCM_j^G, \tag{9}$$

where p_j is the retail price for milk category j, and PCM_j^G is the price-cost margin for milk category j, given pricing conduct G. Assume that these marginal costs are affected by some exogenous cost shifters w according to the following expression

$$\ln(MC_j^G) = a^G + w_j^{'} b^G + e^G, \tag{10}$$

where a^G and b^G are unknown parameters, w_j is a vector of exogenous cost shifters, and e^G are unobservable random shocks to the cost. The test proceeds as follows. First, it estimates the parameters a^G and b^G implied by each supply model. Then evaluate what Rivers and Vuong (2002) call the lack of fit criterion (the opposite of a goodness of fit criterion) for each supply model. The null hypothesis is that the two competing models are asymptotically equivalent when

$$H_0 : \lim_{n \to \infty} [Q_n^G (a^G, b^G) - Q_n^{G'} (a^{G'}, b^{G'})] = 0, \tag{11}$$

where $Q_n^G = \frac{1}{n} \sum (e^G)^2$. The model G is asymptotically better than the model G' when

$$H_1 : \lim_{n \to \infty} [Q_n^G (a^G, b^G) - Q_n^{G'} (a^{G'}, b^{G'})] < 0. \tag{12}$$

On the other hand, the model G' is asymptotically better than the model G when

$$H_2 : \lim_{n \to \infty} [Q_n^G (a^G, b^G) - Q_n^{G'} (a^{G'}, b^{G'})] > 0. \tag{13}$$

Rivers and Vuong (2002) define the test statistic T_n as the variation that characterizes the sample values of the lack of fit criterion and it is given by

$$T_n = \frac{\sqrt{n}}{\sigma_n^{GG'}} [Q_n^G (a^G, b^G) - Q_n^{G'} (a^{G'}, b^{G'})], \tag{14}$$

where n is the sample size and $\sigma_n^{GG'}$ represents the estimated variance of the difference of the lack of fit criterion between the competing models G and G'. Rivers and Vuong (2002) show that T_n is asymptotically normally distributed with mean zero and variance one. Moreover, if

$$T_n < -z_{\frac{\varsigma}{2}},$$

we reject H_0 in favor of H_1; if

$$T_n > z_{\frac{\varsigma}{2}},$$

we reject H_0 in favor of H_2; otherwise, we accept H_0. Here, ς denotes the desired size of the test and $z_{\frac{\varsigma}{2}}$ is the value of the inverse standard normal distribution evaluated at $1 - \frac{\varsigma}{2}$.

4. Results

4.1. Demand results. Table 2 shows the results from estimating equation (3). The results consist of two sets of parameter estimates. First, parameters on price, milk category and fat content dummy variables, and supermarket dummy variables enter the indirect utility linearly and represent the mean utility valuation. Second, consumers' heterogeneity is modeled by allowing the coefficients on price, and milk category and fat content dummy variables to vary with households' income, the number of children, and the unobserved household characteristics, creating a deviation from the mean utility.

Most of the parameter estimates in the mean valuation utility are statistically significant at the 1% and 5% levels. For the average consumer (mean valuation utility), the price, and the whole milk category are of the expected sign. For the private label dummy, the coefficient is negative, implying that, holding everything else constant, the national brand is preferred to the private label or store brand. For the supermarket dummy, the results indicate that, *ceteris paribus*, consumers prefer to shop from Tom Thumb supermarket chain.

However, the parameters vary with households' income and number of children. For instance, the results show that as income increases, the price sensitivity decreases (the interaction between the price and the income is positive); while as the number of children increases, the price sensitivity increases (the interaction between the price and the number of children is positive). In sum, the price sensitivity will increase with the number of children in the household, but will decrease with the household income.

Table 2. Demand parameter estimates

Variable	Estimate	Std. dev.
Price	-3.6175***	1.0185
Whole milk dummy	-2.6567	2.1591
Private label dummy	-2.3590**	1.074
Albertsons dummy	-0.2644***	0.0681
Kroger dummy	-0.5458***	0.0664
Minyard dummy	-0.7840***	0.0762
Winn-Dixie dummy	-0.7000***	0.0687

Table 2 (cont.). Demand parameter estimates

Interactions		
Income	4.4095***	1.7805
Income x Price	1.0512	1.311
Income x Whole milk dummy	1.4907	2.8765
Income x Private label dummy	1.6966	1.6713
# of children	1.326	2.0228
# of children x Price	0.5099*	0.3363
# of children x Whole milk dummy	2.5933**	1.1877
# of children x Private label dummy	1.7645*	1.1094
Dummy		
Unobserved	0.6064	1.4929
Unobserved x Price	0.1998	0.6423
Unobserved x Whole milk dummy	0.4861	2.0138
Unobserved x Private label dummy	-0.6261	2.2995

Note: *** indicates a significance level at 1%, ** significance level at 5%, and * for 10% of significance.

Using equation (4), the own-price elasticities were computed before and after the price war, and the results reported in Table 3. First, the magnitude of the elasticities is very high. This is consistent with the differentiated demand results at the brand-supermarket level, as consumers can switch between brands and supermarket stores (Villas-Boas, 2007; Chidmi and Lopez, 2007). Second, the own-price elasticities for the private label are lower, in absolute value, than the national brand during the two periods. Third, the demand for the supermarket private label becomes less elastic during the price war, while the demand for the national brand (Borden) becomes more elastic. For instance, the own-price elasticity for Borden reduced fat milk in Kroger increases, in absolute value, from 10.5025 to 10.9674; while for the private label, the elasticity decreased from 4.9944 to 2.9239, in absolute value. This may be explained by the fact that as the national brand did not match the price cut, non-loyal consumers shifted to the cheaper private label.

Table 3. Own-price elasticity by brand and supermarket

	Before the price war				During the price war			
Brand-supermarket	Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max
Albertsons								
Reduced fat milk (Borden)	-9.1259	0.6462	-10.5440	-7.5033	-9.3710	0.5070	-10.0428	-8.5591
Reduced fat milk (private label)	-4.9297	0.6204	-6.0855	-4.0286	-3.7414	0.3779	-4.1922	-3.0224
Whole milk (Borden)	-9.1294	0.6398	-11.0989	-8.2448	-9.3184	0.9640	-10.8877	-7.8797
Whole milk (private label)	-7.1197	0.3675	-7.9849	-6.3880	-4.4944	0.5962	-5.2811	-3.3420
Kroger								
Reduced fat milk (Borden)	-10.5025	0.6209	-12.2259	-9.6018	-10.9674	0.5836	-11.8554	-10.2435
Reduced fat milk (private label)	-4.9944	0.3263	-5.6569	-4.2929	-2.9239	0.5195	-3.4865	-1.9809
Whole milk (Borden)	-10.4202	0.8797	-12.8180	-9.3618	-11.9155	0.7789	-13.2387	-10.4720
Whole milk (private label)	-7.6377	0.5656	-8.8609	-6.3707	-3.5650	0.6491	-4.2977	-2.3379
Minyard								
Reduced fat milk (Borden)	-7.5355	0.6091	-8.8424	-6.4721	-7.8372	0.6821	-8.6411	-6.0615
Reduced fat milk (private label)	-6.5219	0.5113	-7.6125	-5.6649	-5.7121	0.6467	-6.6049	-4.6543
Whole milk (Borden)	-6.5544	0.5796	-7.7764	-5.5776	-6.7993	0.5867	-7.6322	-5.3767
Whole milk (private label)	-7.5493	0.7290	-8.9797	-6.2887	-6.8436	1.0466	-8.1623	-5.2742
Winn-Dixie								
Reduced fat milk (Borden)	-11.2373	0.5345	-12.6466	-10.3161	-11.8878	0.6476	-12.5125	-9.8427
Reduced fat milk (private label)	-6.1587	0.4619	-7.2385	-5.1988	-4.4317	0.7854	-5.3843	-2.5984
Whole milk (Borden)	-12.0437	0.6564	-13.6021	-10.9951	-13.2562	0.9380	-14.3030	-10.3272
Whole milk (private label)	-6.8723	0.5787	-8.2583	-5.6984	-5.0172	1.0290	-6.2398	-2.8353
Tom Thumb								
Reduced fat milk (Borden)	-10.6312	0.5432	-11.7583	-9.4974	-10.9207	0.3537	-11.4194	-10.2160
Reduced fat milk (private label)	-6.0129	0.2591	-6.7540	-5.3192	-4.5375	0.3740	-5.0837	-4.0230
Whole milk (Borden)	-10.9301	0.7198	-12.4152	-9.4912	-11.9406	0.4983	-12.6898	-10.8406
Whole milk (private label)	-7.2340	0.4792	-8.3453	-6.0910	-5.7528	0.7800	-6.9483	-4.8561

The evolution of the own-price elasticities, during the whole period of study is presented in Figures 3 and 4. The figures indicate that overall, the own-price elasticities dropped (in absolute value) for all the private label milk. In addition, the drop in own-price elasticities for the supermarket chains that participated in the price war is more accentuated than the one for the supermarket chains that did not participate. At the same time, the price elasticity for the national brand increased in the supermarket chains that participated in the price war compared to the ones that did not. In terms of market share, this translates into an increase of private label sales in Kroger; and a decrease of sales of national brand in Minyard and Albertsons.

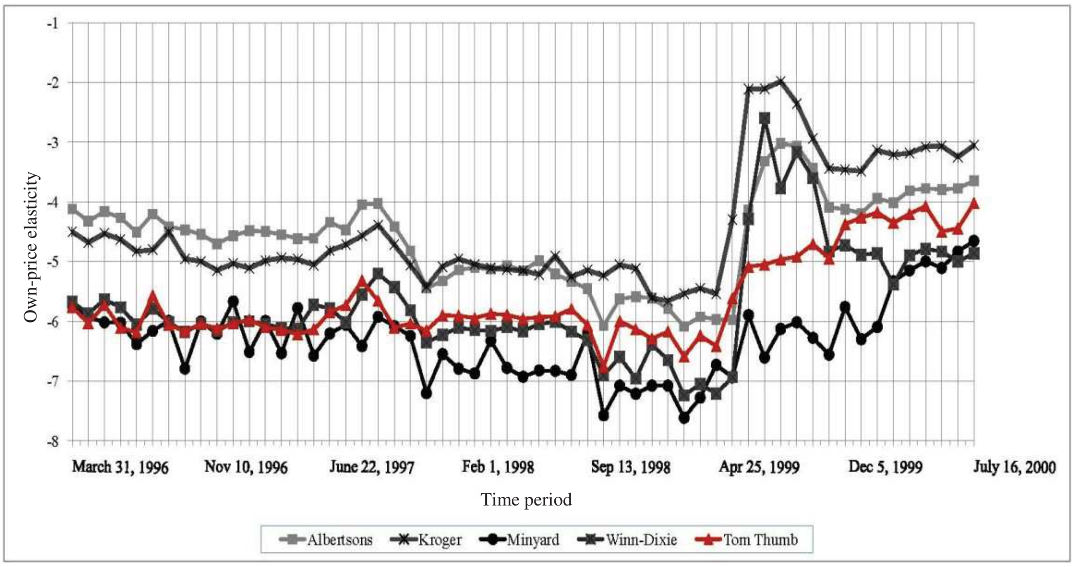

Fig. 3. Evolution of own-price elasticity for private label milk before and during the price war (March 1996-July 2000)

Due to the large dimension of the matrix of cross-price elasticities (400 elasticities), the detailed information on cross-price elasticities is omitted. These elasticities vary from 0.0082 to 1.3819, with an average of 0.2503 and a standard deviation of 0.2770. One general result is that consumers are more loyal to the supermarket chain they shop in. This is evidenced by low cross-price elasticities. However, consumers shift easily between brands inside the same store. For example, the cross-price elasticities between Borden and private label reduced fat milk in Albertsons supermarkets is 1.0491, while it is only 0.0443 between borden reduced fat milk in Albertsons and Borden reduced fat milk in Kroger. Another interesting result is that consumers shift to the private label reduced fat milk whenever the price of the other brands/categories goes up, regardless of the supermarket chain.

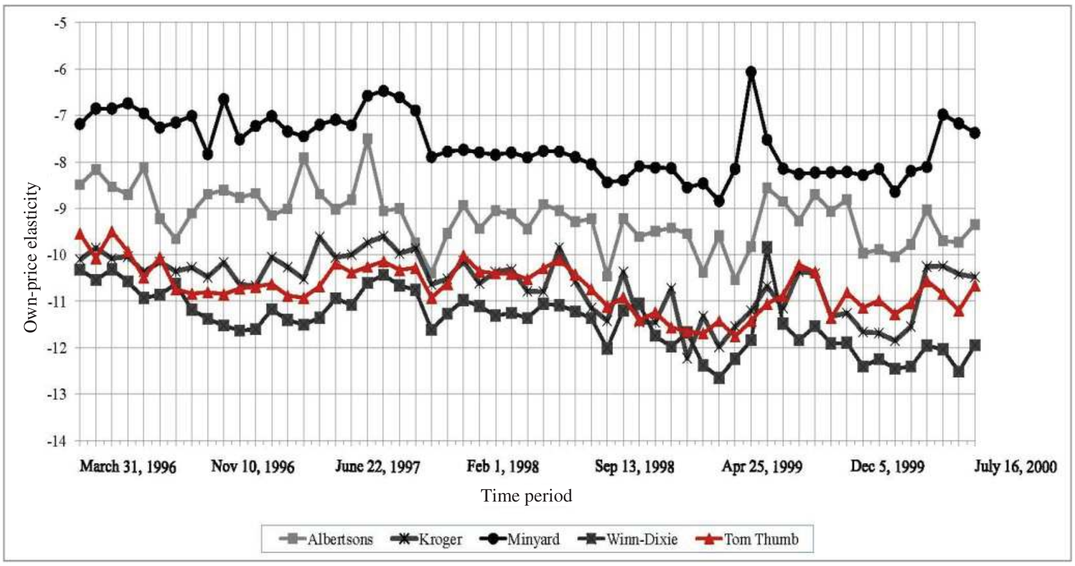

Fig. 4. Evolution of own-price elasticity for national brand before and during the price war (March 1996-July 2000)

4.2. Supply results. Using the results from demand estimates, the price-cost margins for each brand were estimated. For the period before the price war, we estimated a Bertrand-Nash game and a perfectly collusive pricing game. The recovered marginal cost from the first period was regressed on input variables in order to obtain prediction of the marginal cost during the price war period and hence the corresponding price-cost margins.

A summary of the Lerner index for the first period is given in Table 4. For the Nash-Bertrand game, the Lerner index ranges from 7.9576% for Borden whole milk in Winn-Dixie supermarket chain to 23.9179% for private label reduced fat milk in Kroger, with an average of 14.6284% and a standard deviation of 3.4128%. Notice that the Lerner index for private labels, in all supermarket chains, except Minyard, is greater than the Lerner index for the national brand. Also, the difference between Lerner indexes across supermarket chains is statistically not significant. However, the Lerner index is statistically different from zero, implying that supermarket chains exercise some market power when they set the price of fresh milk. On average, for each dollar consumers pay for milk, supermarket chains get approximately 15 cents.

Table 4. Lerner index before the price war by brand and supermarket

	Nash-Bertrand game				Perfectly collusive pricing game			
	Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max
Brand-supermarket								
Albertsons								
Reduced fat milk (Borden)	14.4503	1.1338	11.9897	17.6207	60.4153	4.8451	48.7230	70.1316
Reduced fat milk (private label)	21.7227	2.4015	17.6050	25.8300	95.1658	10.3863	74.3302	112.3707
Whole milk (Borden)	13.1280	0.8521	10.5681	14.5308	46.9135	3.7605	36.0173	54.1678
Whole milk (private label)	16.9212	0.9359	14.7391	18.5112	67.7811	5.0679	55.5467	75.4733
Kroger								
Reduced fat milk (Borden)	11.9062	0.6805	10.0957	12.8847	53.7301	4.5094	43.2693	64.7772
Reduced fat milk (private label)	20.6280	1.3855	18.1124	23.9179	96.3328	7.6546	81.3511	110.1099
Whole milk (Borden)	10.9804	0.8996	8.8058	12.2631	42.7090	4.1416	33.4996	51.5999
Whole milk (private label)	15.1794	1.1558	13.0366	17.9424	65.4371	5.9927	54.0881	81.5966
Minyard								
Reduced fat milk (Borden)	15.0243	1.2493	12.9504	17.2752	71.3311	6.9116	58.1484	88.2840
Reduced fat milk (private label)	16.4360	1.3242	13.9352	18.8437	90.3447	8.6336	72.9945	108.1892
Whole milk (Borden)	16.3752	1.4353	13.6289	19.0011	56.5369	5.5625	45.1202	69.8491
Whole milk (private label)	15.2691	1.5293	12.5399	17.8983	66.8267	7.1618	53.6194	83.5646
Winn-Dixie								
Reduced fat milk (Borden)	9.8110	0.4787	8.5963	10.6721	50.4264	3.5516	43.0307	59.7383
Reduced fat milk (private label)	16.8839	1.2447	14.2377	19.9203	92.7581	8.5183	74.6021	112.0166
Whole milk (Borden)	9.1371	0.5312	7.9576	9.9768	37.9979	2.9528	31.3034	45.4385
Whole milk (private label)	15.2443	1.2549	12.5689	18.2691	70.1517	6.7236	55.1888	87.3805
Tom Thumb								
Reduced fat milk (Borden)	10.8979	0.4643	10.0849	11.9205	52.6061	3.8898	44.7468	61.7623
Reduced fat milk (private label)	17.2147	0.7296	15.3156	19.3451	87.4088	6.2779	72.4270	100.1062
Whole milk (Borden)	10.1797	0.6114	9.0501	11.5513	40.9538	3.4466	32.9898	48.3627
Whole milk (private label)	15.1791	0.9133	13.2485	17.8741	68.2786	5.9042	55.6304	79.7041

For the collusive pricing game, the Lerner index ranges from 31.3034% for Borden whole milk in the Winn-Dixie supermarket chain to 112.3707% for private label reduced fat milk in Kroger, with an average of 65.7053% and a standard deviation of 18.6412%. Notice that the Lerner index exceeds 100% in some instances, implying a negative marginal cost. This can serve as an informal and intuitive test to reject the collusive pricing game.

Estimating the price-cost margins allows us to recover the total marginal cost for the first period. Table 5 gives the average marginal cost for each brand and supermarket before the price war and for each pricing game. For the sake of completeness, the regression results of the recovered marginal cost from the period before the war on the farm milk price, wage rate, electricity cost, and a producer price index for packaging, interest rate, and store dummies are reported on Table 6. The parameters of this regression are then used to predict the marginal cost that prevails during the price war, and therefore the price-cost margins for that period. In addition, the recovered marginal cost is also used to implement the Vuong (1989) test. The result of the test suggests that Nash-Bertrand game outperforms the collusive pricing game.

Table 5. Recovered marginal cost ($/gallon) before the price war by brand and supermarket

	Nash-Bertrand game				Perfectly collusive pricing game			
	Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max
Brand-supermarket								
Albertsons								
Reduced fat milk (Borden)	3.3044	0.3126	2.5446	3.9940	1.5391	0.2998	0.9226	2.2938
Reduced fat milk (private label)	2.2707	0.3307	1.8024	2.9386	0.1704	0.3330	-0.3196	0.8963
Whole milk (Borden)	3.1438	0.2726	2.7935	3.9559	1.9272	0.2734	1.5564	2.8000
Whole milk (private label)	2.5563	0.1952	2.3177	3.0641	0.9978	0.2169	0.7176	1.5976

Table 5 (cont.). Recovered marginal cost ($/gallon) before the price war by brand and supermarket

	Nash-Bertrand game				Perfectly collusive pricing game			
	Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max
Kroger								
Reduced fat milk (Borden)	3.9648	0.3131	3.5393	4.8488	2.0928	0.3459	1.4869	3.0596
Reduced fat milk (private label)	2.2489	0.2098	1.8651	2.7778	0.1169	0.2316	-0.2835	0.6058
Whole milk (Borden)	3.6846	0.3976	3.1300	4.7818	2.3825	0.3990	1.9206	3.4674
Whole milk (private label)	2.7354	0.2619	2.2206	3.2847	1.1261	0.2778	0.4980	1.7285
Minyard								
Reduced fat milk (Borden)	2.6684	0.2863	2.1971	3.2563	0.9157	0.2951	0.3377	1.5281
Reduced fat milk (private label)	2.5608	0.2784	2.1094	3.1363	0.3165	0.2939	-0.2342	0.9812
Whole milk (Borden)	2.3704	0.2535	1.9447	2.9030	1.2417	0.2619	0.7952	1.8300
Whole milk (private label)	2.6772	0.3305	2.1535	3.3301	1.0666	0.3308	0.4767	1.7660
Winn-Dixie								
Reduced fat milk (Borden)	4.4075	0.2832	3.9308	5.2187	2.4288	0.2971	1.8851	3.2313
Reduced fat milk (private label)	2.4668	0.2538	1.9580	3.0839	0.2333	0.2822	-0.3306	0.9023
Whole milk (Borden)	4.4257	0.3167	3.8813	5.2354	3.0253	0.3217	2.5699	3.7985
Whole milk (private label)	2.5132	0.2654	1.9806	3.1688	0.8986	0.2809	0.3467	1.6241
Tom Thumb								
Reduced fat milk (Borden)	4.1151	0.2705	3.5539	4.7367	2.1960	0.2975	1.6782	2.8886
Reduced fat milk (private label)	2.6203	0.1602	2.2164	3.0311	0.4065	0.2219	-0.0031	0.9449
Whole milk (Borden)	3.9296	0.3292	3.2451	4.5876	2.5906	0.3330	2.0123	3.3560
Whole milk (private label)	2.5923	0.2297	2.1010	3.1099	0.9798	0.2519	0.5192	1.5733

Table 6. Marginal cost parameter estimates

	Nash-Bertrand game		Perfectly collusive pricing game	
Variable	Estimate	Std. dev.	Estimate	Std. dev.
Intercept	4.1971	2.9624	6.013	3.7205
Farm price	0.6449***	0.1899	0.6472***	0.2385
Wage	0.2165***	0.0867	0.1815*	0.1089
Electricity	0.0014	0.2006	-0.1986	0.2519
Packaging	-3.1259	2.1072	-5.3173**	2.6465
Interest	-12.7548***	4.8386	-10.0273*	6.0768
Albertsons dummy	-0.4955***	0.0739	-0.3846***	0.0928
Kroger dummy	-0.1559**	0.0739	-0.1136	0.0928
Minyard dummy	-0.7451***	0.0739	-0.6581***	0.0928
Winn-Dixie dummy	0.1390*	0.0739	0.1033	0.0928

Vuong test:

$$T_n = \frac{\sqrt{n}}{\sigma_n^{GG'}}[Q_n^G(a^G, b^G) - Q_n^{G'}(a^{G'}, b^{G'})] = -35.3106.$$

For ς = 5%, T_n = – 35.3106 is less than the critical value of -1.96. Therefore, H_0 (the two models are equivalent) is rejected in favor of H_1 (the Nash-Bertrand is better than the perfectly collusive pricing model).

Table 7 gives the Lerner index during the price war. Notice that the Lerner index for Nash-Bertrand game (the game that best fits the data) is negative for the entire private label except in Minyard supermarket chain. Another key result is that the decline is more noticeable for the supermarket chains that actively participated in the price war, such as Kroger, and Winn-Dixie, than for the other supermarkets. Moreover, except for the Minyard supermarket chain, all the supermarket chains lost money selling the private label whole and reduced fat milk. For instance, Kroger supermarket chain has its margin drop from 20.63% to a negative margin of 61.49% for its branded reduced fat milk. Finally, the market share of Kroger (supermarket chain that started the price cut) reduced fat milk private label increased for four periods following the price cut and reverted to its normal trend after; while the biggest lost in market share was from Albertsons supermarket chain (see Figure 5).

Table 7. Lerner index during the price war by brand and supermarket

	Nash-Bertrand game				Perfectly collusive pricing game			
	Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max
Brand-supermarket								
Albertsons								
Reduced fat milk (Borden)	43.22	19.74	5.00	70.61	88.69	22.85	45.65	122.42
Reduced fat milk (private label)	-10.29	43.91	-92.33	43.10	77.31	46.66	-10.04	143.41
Whole milk (Borden)	35.75	24.85	-8.77	67.76	86.41	25.92	37.76	124.77
Whole milk (private label)	-21.36	51.74	-121.71	37.95	74.58	52.51	-26.85	147.33

Table 7 (cont.). Lerner index during the price war by brand and supermarket

	Nash-Bertrand game				Perfectly collusive pricing game			
	Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max
Kroger								
Reduced fat milk (Borden)	50.94	14.71	24.25	71.56	89.41	18.88	56.20	117.55
Reduced fat milk (private label)	-61.49	76.71	-214.10	21.13	58.51	69.07	-81.63	148.67
Whole milk (Borden)	49.68	14.88	20.01	71.08	89.21	19.36	53.75	117.84
Whole milk (private label)	-63.86	78.86	-220.43	20.35	57.72	70.34	-85.29	149.15
Minyard								
Reduced fat milk (Borden)	26.24	23.70	-25.07	56.67	85.55	28.71	35.68	128.26
Reduced fat milk (private label)	15.40	14.58	-7.77	39.22	86.77	31.18	39.09	139.65
Whole milk (Borden)	14.46	24.45	-38.21	47.76	83.90	32.42	32.39	134.08
Whole milk (private label)	16.75	14.11	-5.71	39.06	87.23	30.58	40.93	139.75
Winn-Dixie								
Reduced fat milk (Borden)	52.03	16.71	11.19	73.31	86.22	18.03	46.91	111.44
Reduced fat milk (private label)	-34.16	70.66	-220.60	36.00	57.15	59.97	-91.66	127.44
Whole milk (Borden)	51.25	17.58	7.28	73.41	85.88	18.54	44.57	111.40
Whole milk (private label)	-38.99	78.78	-226.25	35.93	54.60	64.02	-95.04	127.47
Tom Thumb								
Reduced fat milk (Borden)	41.25	14.71	16.17	62.60	78.81	18.38	48.44	106.48
Reduced fat milk (private label)	-14.57	17.60	-40.53	16.48	61.27	31.12	10.71	114.47
Whole milk (Borden)	39.44	16.12	12.11	62.35	77.95	19.22	46.51	106.52
Whole milk (private label)	-19.49	17.03	-42.55	10.10	60.12	31.71	9.43	115.57

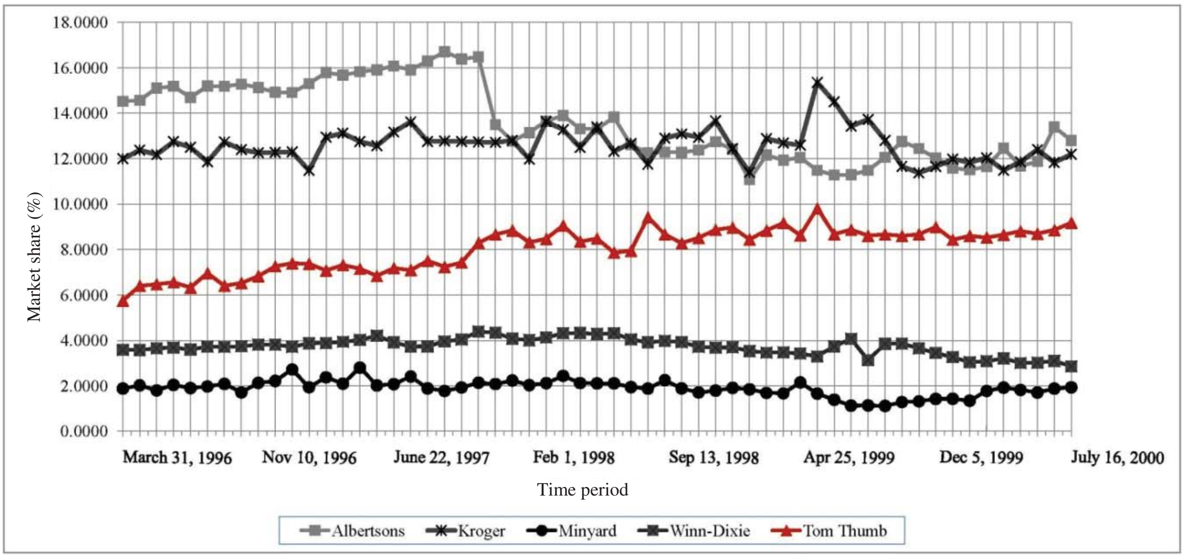

Fig. 5. Evolution of market share for private label milk before and after the price war (March 1996-July 2000)

Conclusions

In this paper we develop a model that estimates the effect of a price war on fluid milk market performance in the DFW supermarket industry. The paper uses a structural model of demand and pricing behavior to estimate the demand for fluid milk and the price-cost margins at the brand-supermarket chain level for two pricing games: Nash-Bertrand and collusive pricing game. The data sample was divided into two sub-samples. The first one, before the price war, is used to estimate the price-cost margins and recover the marginal cost. The second one, during the price war, is used to obtain the price-cost margins estimates from the forecasts of the marginal cost. For the demand estimation, the full sample was used.

The demand results show that consumer' price sensitivity changes during the price war, implying more elastic demand for some supermarket/brands and less elastic demand for others. Hence, the demand for the supermarket/brands, especially private labels, that participated aggressively in the price war become less elastic, while the demand for the supermarket/brands (national brand) that did not participate in the price war become more elastic. In addition, the price sensitivity for the national brand increased in the supermarket chains that participated in the price war compared to the ones that did not.

The supply results show the Nash-Bertrand game outperforms the collusive pricing game, implying that the five supermarket chains do not collude in setting the fluid milk retail prices. For the Nash-Bertrand game, the Lerner index before the price war is positive and greater than zero for all supermarket/brands, attesting to the existence of market power of supermarket chains to price the fluid milk. In most supermarket chains, retailers make more profit selling their own brand than selling the national brand. During the price war, the price-cost margins drop for all private label brands in all supermarkets except Minyard. Additionally, the retailers make more profit selling the national brand than selling their own private brands. Worse, the retailers that participated in the price war lose money selling their private brands.

Though our model assumes a Bertrand-Nash game and collusive pricing game with no dynamics, it offers an easy way to study the pricing behavior of firms when they deviate from profit-maximization behavior. The cost shocks could easily be integrated in the analysis by allowing different cost shock scenarios. In addition, other pricing conduct, such as price leadership can be considered in order to improve our understanding of this particular price war.

References

1. Applebaum E. Estimation of the Degree of Oligopoly Power // *Journal of Econometrics*, 2006. – № 19. – pp. 287-289.
2. Blumenthal W., D. Cohen. Channels of Distribution as Merger Markets: Interpreting Staples and Cardinal // Antitrust Report, Federal Trade Commission, 1998. – № 2.
3. Carman H., R. Sexton. Supermarket Fluid Milk Pricing Practices in the Western United States // *Agribusiness: An International Journal*, 2005. – № 21. – pp. 509-530.
4. Chidmi B., R.A. Lopez. Brand-Supermarket Demand for Breakfast Cereals and Retail Competition // *American Journal of Agricultural Economics*, 2007. – № 89. – pp. 324-327.
5. Chidmi B., R.A. Lopez, R.W. Cotterill. Retail Oligopoly Power, Dairy Compact, and Boston Milk Prices // *Agribusiness: An International Journal*, 2005. – № 21. – pp. 477-491.
6. Champsaur P., J.C. Rochet. Concurrence par les Prix et Varieté des Produits // *Annales D'Economie et de Statistiques*, 1986. – № 1. – 8 p.
7. Chidmi B., R.A. Lopez. Brand-Supermarket Demand for Breakfast Cereals and Retail Competition // *American Journal of Agricultural Economics*, 2007. – № 89. – pp. 224-237.
8. Corts K. Conduct Parameters and the Measurement of Market Power // *Journal of Econometrics*, 1999. – № 88. – pp. 227-250.
9. Dubé J.P., S. Gupta. Cross-Brand Pass-Through in Supermarket Pricing // *Marketing Science*, 2008. – № 27. – pp. 324-333.
10. Gollop F., M. Roberts. Firm Interdependence in Oligopolistic Markets // *Journal of Econometrics*, 1979. – № 1. – pp. 313-331.
11. Iwata G. Measurement of Conjectural Variations in Oligopoly // *Econometrica*, 1974. – № 42. – pp. 947-966.
12. Levy D., H. Chen, G. Muller, S. Dutta, M. Bergen. Holiday Price Rigidity and Cost Price Adjustment // *Economica*, 2010. – № 77. – pp. 172-198.
13. Liang G. Bank Profits, Risk, and Local Market Concentration // *Journal of Economics and Business*, 1989. – № 41. – pp. 297-305.
14. Nevo A. A Practitioner's Guide to Estimation of Random Coefficients Logit Models of Demand // *Journal of Economics and Management Strategy*, 2000. – № 9. – pp. 513-538.
15. Pofahl G.M., T.J. Richards. The Valuation of New Products in Attribute Space // *American Journal of Agricultural Economics*, 2009. – № 91. – pp. 402-415.
16. Porter R. A Study of Cartel Stability: The Joint Executive Committee, 1880-1886 // *The Bell Journal of Economics*, 1983. – № 14. – pp. 301-314.
17. Richards T. A Nested Logit Model of Strategic Promotion // *Quantitative Marketing and Economics*, 2007. – № 5. – pp. 63-91.
18. Rivers D., Q. Vuong. Model Selection Tests for Nonlinear Dynamic Models // *Econometrics Journal*, 2002. – № 5. – pp. 1-39.
19. Rotenberg J., G. Saloner. A Supergame-Theoretic Model of Price Wars during Booms // *American Economic Review*, 1986. – № 76. – pp. 390-407.
20. Schendel D., P. Balestra. Rational Behavior and Gasoline Price Wars // *Applied Economics*, 1969. – № 1. – pp. 89-101.
21. Slade M. Product Rivalry with Multiple Strategic Weapons: An Empirical Analysis of Price and Advertising Competition // *Journal of Economics and Management Strategy*, 1995. – № 3. – pp. 445-476.
22. Slotegraff R.J., K. Pauwels. The Impact of Brand Equity and Innovation on the Long-Term Effectiveness of Promotions// *Journal of Marketing Research*, 2008. – № 45. – pp. 293-306.
23. Villas-Boas S. Vertical Relationships between Manufacturers and Retailers: Inference with Limited Data // *Review of Economic Studies*, 2007. – № 74. – pp. 625-652.
24. Vuong Q. Likelihood Ratio Tests for Model Selection and Non-Nested Hypotheses // *Econometrica*, 1989. – № 57. – pp. 307-333.