Food Marketing Policy Center

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A Study of the Boston Fluid Milk Market
and the North East Dairy Compact**

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University of Connecticut
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Preface

This study develops a two-stage market channel model to analyze pricing in the Boston milk market where retailers are differentiated sellers. A nonlinear model of demand and costs, including firm specific and industry cost shift variables is estimated for each of the four leading supermarkets. Cost pass through rates for industry wide shifts are near 100%; for firm specific costs they range between 32 and 47 percent, suggesting that substantial differentiation and related market power. A test for focal point collusion finds that channel firms elevated retail prices when the Northeast Dairy Compact elevated and stabilized raw milk prices.

Key words: price transmission, industry versus firm specific cost inputs, differentiated product oligopoly, focal point collusion

1. Introduction

Research on the economics on price transmission has concentrated almost exclusively on homogeneous products, aggregate national data and models that assume the market channel is a single industry of competitive firms. Many studies typically are reduced form time-series analysis of the relationship of input or wholesale prices and retail prices, with no attention to the underlying structural model of the marketing channel (Kinnucan and Forker 1987, Borenstein et al. 1997). During the 1980's theoretical analysis of price transmission in noncompetitive markets received attention. Studies include Bulow and Pfleidere (1983) and Seade (1985). Empirical studies in noncompetitive industries that focused on the issue of tax overshifting (transmission above 100%) include Sumner (1981) and Karp and Perloff (1989). The latter study shows that estimated pass through rates are biased if one applies a perfect competition model to oligopoly. In international trade Goldberg and Knetter (1997) review studies that analyze pass through of changes in exchange rates. In food industries McCorriston et al. (1998) analyze price transmission in noncompetitive markets.

All of these studies use homogeneous product models and focus on industry wide cost shocks. Ashenfelter et al., (1998) working on the Staples-Office Depot merger case analyzes firm specific as well as industry wide cost shocks in a differentiated product industry, but do so only in a residual demand framework. None of these studies analyze price transmission in a multi-stage market channel.

In this paper we develop a more general model for the analysis of price transmission, or what is alternatively called the cost pass through rate (CPTR). We specify two stages in the fluid milk marketing channel, processing and retailing, and we estimate CPTRs for individual firms in a differentiated product oligopoly at each stage of the marketing channel. This structural approach explicitly measures CPTRs for firm specific as well as industry wide cost shocks.

To measure both types of cost pass through we advance the theory and empirical analysis by introducing a more disaggregate structural model that identifies strategic cross firm price shocks and corresponding pass through rates. Given an oligopolistic market structure, a firm specific shock may not only influence that firm's own price level; it also may cause other firms to react to that price and change their prices (Dunne and Roberts 1992, Cotterill, Putsis and Dhar 2000). Our structural model specification is more general than the Ashenfelter et al. residual demand approach because it measures cross price effects, price impacts on all firms (brands) in the market as opposed to just one or two marginal firms, and it allows us to specify alternative conduct games and test to determine which best replicates observed market conduct.

This paper uses Information Resources Inc. (IRI)-Infoscan database for fluid milk products for each of the top four supermarket chains in Boston (Stop & Shop, Shaw's, Star Market and DeMoulas). The data are for four week periods from March 1996 to July 1998. This period includes the elevation and stabilization of the farm level fluid milk price due to the advent of the Northeast Dairy Compact (NEDC). Thus we are able to analyze how each chain and fluid milk processor changed retail milk prices when this agricultural policy changed the key industry cost variable, raw milk price. The evidence strongly suggests that processors and retailers exercised market power at compact implementation thereby increasing margins and retail prices by more than one would have expected from the routine pass through of market generated changes in raw milk price.

2. Cost Pass Through Models for a Market Channel with Differentiated Product Oligopolies

Here we specify horizontal competition both at the processing and retail level as Nash in prices and assume Bertrand price competition exists among retailers in a differentiated product oligopoly. Processors and retailers may play different pricing games in the vertical channel. We specify three different games: supermarkets with upstream integration (complete vertical coordination game), a vertical Nash model where each supermarket chooses an exclusive processor and processors and retailers maximize profit simultaneously by deciding, in arms length fashion, on the wholesale and retail price, and finally a vertical Stackelberg game where in the first stage a retailer decides on the profit maximizing price and then a processor maximizes profit taking into account the reaction function of the retailer.

Our work assumes vertical dyadic relationships between processors and retailers, i.e. each retailer deals with one exclusive processor of milk. Other research on vertical structure models has the same constraint, e.g. Kadiyali, Vilcassim and Chintagunta (1996, 1998). For this market the assumption is not an extreme departure from actual organization. Stop & Shop processed all of its private label and Hood brand milk (under license from Hood) in its own plant. The other chains each received all of their private label milk and a leading brand of milk from a single processor. In each case this accounted for more than 75% of milk sales. We model competition among processors as a vertical game through retailers rather than a direct horizontal game among processors at the wholesale level. This seems sufficient and reasonable. Processors compete with each other, contingent on retailer behavior, in the retail market for the sale of their products.

For simplicity of exposition we present a two retailer, two processor model and discuss generalization to 3 or more firms only where the results differ. In the empirical section of this paper we estimate the model with four retailers and four processors.

Let the demand functions of the retailers be the following:

$$q_1 = a_0 + a_1 p_1 + a_2 p_2 \quad (1a)$$
$$q_1 = b_0 + b_1 p_1 + b_2 p_2. \quad (1b)$$

Processor level demand is derived from the retail level demand specifications given retail conduct and margin. To derive these processor level demand functions different conjectures are assumed at the processor level concerning retailer reactions. These conjectures can be perceived as assumptions by the processors about retailer pricing behavior given a wholesale price. For the vertical integration (full coordination) game we need no vertical conjecture assumptions.

Let the retailer's cost function be the following:

$$TC_1 = w_1 * q_1 \quad (2a)$$
$$TC_1 = w_2 * q_2, \quad (2b)$$

where w_1 and w_2 are the wholesale prices received by the processors. So, the retailers' profit functions can be written as:

$$\boldsymbol{P}_1^R = (p_1 - w_1) * q_1 \quad (3a)$$
$$\boldsymbol{P}_2^R = (p_2 - w_2) * q_2. \quad (3b)$$

Following Choi (1991), in the Vertical Nash game, a linear mark-up at retail is conjectured by the processor on retail price; so, retail price can be written as:

$$p_1 = w_1 + r_1 \quad (4a)$$
$$p_2 = w_2 + r_2, \quad (4b)$$

where r_1 and r_2 are the linear mark-up at the retail level.

In the Stackelberg game, each processor develops a conjecture from the first order condition of the retailer. The retailer's first order conditions are:

$$p_1 = \frac{1}{2} w_1 - \frac{1}{2a_1}\left(a_0 + a_2 p_2\right) \quad (5a)$$

$$p_2 = \frac{1}{2} w_2 - \frac{1}{2b_2}\left(b_0 + b_1 p_1\right). \quad (5b)$$

We assume that each manufacturer only knows its own retailer's reaction function, i.e. the manufacturer does not know, and thus ignores the impact of its wholesale price change on the other retail price. The resulting Stackelberg conjectures are:

$$\left.\frac{\partial p_1}{\partial w_1}\right|_{Conjecture} = \frac{1}{2} \text{ and } \left.\frac{\partial p_2}{\partial w_2}\right|_{Conjecture} = \frac{1}{2}.$$

In fact, once we have estimated the model, testing the estimated CPTRs against the conjecture values for vertical Nash (1) and manufacturer Stackelberg (1/2) gives us information on which is the most appropriate game.

We simplify the processor level marginal cost function in the following manner:

$$wmc_1 = m + m_1 \quad (6a)$$
$$wmc_2 = m + m_2, \quad (6b)$$

where m is the industry specific marginal cost component and m_1 and m_2 are the processor specific cost components. So, the processors profit functions can be written as:

$$Đ_1^P = (w_1 - m - m_1) * q_1 \quad (7a)$$
$$Đ_2^P = (w_2 - m - m_2) * q_2. \quad (7b)$$

Using the profit maximizing first order conditions both at the processing and retail level we derive the cost pass through rate (CPTR) equations. Table 1a gives the CPTR for farm to wholesale and from wholesale to retail for the vertical Nash and vertical Stackelberg games. The channel cost pass through rate is decomposed into the rate from farm to wholesale and from wholesale to retail. We also give the parameter values for a special case: retail monopoly.

Slade (1995), Choi (1991), Cotterill, Putsis and Dhar (2000) and others have modeled vertical interaction by assuming that retail sales are made by a monopolist that is supplied by more than one manufacturer. Here we assume the converse (multiple retailers each supplied by a single manufacturer). Tables 1a and 1b give detailed comparative static results for our models. In general the pass through rates are complex functions of the model's parameters. If in fact our retailers are monopolists the results collapse to numerical ratios. Row one of Table 1a indicates that the transmission rates for changes in processor's marginal costs to the wholesale price are 1/2 for manufacturer Stackelberg and 2/3 for vertical Nash. For the CPTR between a firm's own wholesale and retail prices (Row 7, Table 1a), if we have retail monopolies the rates for both the vertical Nash and Stackelberg game reduce to1/2.

Note that in the retail monopoly case industry wide and firm specific cost shocks produce identical pass through rates. In the more general case this is not true. One can have effectively competitive (100%) pass through of industry wide cost shocks but nonzero, imperfectly competitive pass through of firm specific cost shocks. Thus if manufacturer firm-specific CPTR are not zero we have an affirmative test for market power in the manufacturing industry.[1]

Let us now examine pass through from wholesale to retail. Even if we do not observe retail monopoly, i.e. the quantity of milk sold at one chain is sensitive to the prices charged by one or more of the other chains, individual retail chains may also possess a modicum of market power. In other words retail level firm specific CPTRs (Rows 7 and 10, Table 1a) may be positive rather than zero.

An important theoretical result emerges from our analysis of firm and industry cost shocks. Studies of price transmission at the industry level can not definitively rule out the exercise of market power at the firm level. Studies that characterize differentiated product industries as homogeneous and employ aggregate industry data miss firm specific effects. In our differentiated product model one can have 100% pass through of an industry wide cost shock, the "competitive" result at the industry level, but at the same time observe nonzero firm specific cost shocks, the noncompetitive result at the firm level. If an industry is effectively competitive we expect that none of a firm specific cost shock (such as a merger-specific efficiency gain) would be passed on to consumers. In an imperfectly competitive industry some but by no means all of a cost shock would be passed on to consumers. Moreover a merger that decrease competition may actually increase pass through of firm specific efficiencies.

One can also derive the cost pass through impact of processor specific cost shocks on retail prices. We call these total cost pass through rates. The following total CPTR relationships hold:

- In the case of industry wide shock:

$$\frac{dp_1}{dm} = \left(\left.\frac{dp_1}{dw_1}\right|_{dw[1]=0} * \left.\frac{dw_1}{dm}\right|_{dm[1]=dm[2]=0} \right) + \left(\left.\frac{dp_1}{dw_2}\right|_{dw[1]=0} * \left.\frac{dw_2}{dm}\right|_{dm[1]=dm[2]=0} \right) \tag{8a}$$

$$\frac{dp_2}{dm} = \left(\left.\frac{dp_2}{dw_1}\right|_{dw[2]=0} * \left.\frac{dw_1}{dm}\right|_{dm[1]=dm[2]=0} \right) + \left(\left.\frac{dp_2}{dw_2}\right|_{dw[1]=0} * \left.\frac{dw_2}{dm}\right|_{dm[1]=dm[2]=0} \right). \tag{8b}$$

- Similarly, for channel specific shocks:

$$\frac{dp_1}{dm_1} = \left(\left.\frac{dp_1}{dw_1}\right|_{dw[2]=0} * \left.\frac{dw_1}{dm_1}\right|_{dm=dm[2]=0} \right) + \left(\left.\frac{dp_1}{dw_2}\right|_{dw[1]=0} * \left.\frac{dw_2}{dm_1}\right|_{dm=dm[2]=0} \right) \tag{9a}$$

$$\frac{dp_2}{dm_1} = \left(\left.\frac{dp_2}{dw_1}\right|_{dw[2]=0} * \left.\frac{dw_1}{dm_1}\right|_{dm=dm[2]=0} \right) + \left(\left.\frac{dp_2}{dw_2}\right|_{dw[1]=0} * \left.\frac{dw_2}{dm_1}\right|_{dm=dm[2]=0} \right) \tag{9b}$$

$$\frac{dp_1}{dm_2} = \left(\left.\frac{dp_1}{dw_1}\right|_{dw[2]=0} * \left.\frac{dw_1}{dm_2}\right|_{dm=dm[1]=0} \right) + \left(\left.\frac{dp_1}{dw_2}\right|_{dw[1]=0} * \left.\frac{dw_2}{dm_2}\right|_{dm=dm[1]=0} \right) \tag{10a}$$

$$\frac{dp_2}{dm_2} = \left(\left.\frac{dp_2}{dw_1}\right|_{dw[2]=0} * \left.\frac{dw_1}{dm_2}\right|_{dm=dm[1]=0} \right) + \left(\left.\frac{dp_2}{dw_2}\right|_{dw[1]=0} * \left.\frac{dw_2}{dm_2}\right|_{dm=dm[1]=0} \right). \tag{10b}$$

Table 1b gives the formulae for the total CPTR and their values if we observe retail monopolies. The same

[1] Ashenfelter et al. (p 7) also make this point, observing that perfect competition requires zero pass through of firm specific shocks.

qualitative analysis of industry and firm specific effects holds.

Table 1b also gives the CPTR for the integrated or fully coordinated (perfect vertical tacit collusion) game. Note that when one eliminates the double margnialization that occurs in the vertical Nash and Stackelberg games the pass through rates, in the retail monopoly case, increase to 1/2. Conversely evolution of a channel into successive monopolies at several stages with non-coordinated pricing reduces price transmission. This issue is clearly on the table in many food industries where powerful manufacturers sell to powerful retailers. In such industries the substitution of vertical strategic alliances for arms length pricing can improve channel performance for consumers and shareholders.[2]

3. Variable Definitions and Model Specification

We use IRI scanner data that include quantities sold, average price per gallon, average package size sold, for the four leading retail chains (Stop & Shop, Shaw's, Star Market, and DeMoulas) in the Boston market. The data series starts in March 1996 and each observation is a four-week period with thirteen observations for each calendar year.[3] The fluid milk category covers disappearance of skim/low fat and whole milk within a retail chain. In the present model, farm level fluid milk price will be taken as exogenous. We use the Boston Federal Milk Marketing Order Class-I milk pay price for the farm level milk price series.[4] Since the Federal Milk Marketing Order sets this price, based on national manufacturing milk prices and a differential set in the 1995 farm law, the assumption that the farm level fluid prices for Boston are exogenous is not unrealistic. Demand for fluid milk in Boston does not appreciably affect the national supply-demand system for manufacturing milk upon which the New England farm level fluid price is based.

To identify the demand side we specify weighted average percentage price reduction, a measure of trade promotion activity, for each retailer in each demand equation. To identify the supply side we specify the measure of volume per unit, for each retail chain. Variation in average volume per unit (e.g. shifting from 0.25 to 1 gallon per unit sold) captures exogenous cost components related to package size; so, we use it as a supply side variable.

4. Empirical Estimation Procedure

To estimate our models, we specify the fluid milk demand equations for retailers and the appropriate profit maximizing first order conditions. We specify linear demand functions for the convenience of estimation and tractability. The demand equations are:

$$
\begin{aligned}
q_{SS} &= i_1 + a_1 p_{SS} + a_2 p_{Sh} + a_3 p_{SM} + a_4 p_D \\
&\quad + J_{SS} WRR_{SS} \\
q_{Sh} &= i_2 + b_1 p_{SS} + b_2 p_{Sh} + b_3 p_{SM} + b_4 p_D \\
&\quad + J_{Sh} WRR_{Sh} \\
q_{SM} &= i_3 + c_1 p_{SS} + c_2 p_{Sh} + c_3 p_{SM} + c_4 p_D \\
&\quad + J_{SM} WRR_{SM} \\
q_D &= i_4 + d_1 p_{SS} + d_2 p_{Sh} + d_3 p_{SM} + d_4 p_D \\
&\quad + J_D WRR_D ,
\end{aligned}
\tag{11a-d}
$$

where, q and p are quantity and price variables; and the subscript *SS*-Stop & Shop, *Sh*-Shaw's, *SM*-Star Market and *D*-DeMoulas. We close the model with the following linear marginal/average cost function:

$$mc_i = m_i + m + h_i VPU_i \, , \tag{12}$$

where, m_i $(i = SS, Sh, SM, D)$ are the firm specific unobserved (to the econometrician) cost component, m is the price of raw milk, and VPU_i (volume per unit) captures the cost components related to packaging.[5] The unobserved cost component will be estimated within the system as the intercept for each firm's first order condition. The coefficient on m is restricted to be 1

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[2] Finally note that in Table 1a-b that $(dw_1/dm_1 = dw_2/dm_2)$, $(dp_1/dw_1 = dp_2/dw_2)$ and $(dp_1/dm_1 = dp_2/dm_2)$ in this two-person game, however this is unique t the two processor-two retailer vertical dyadic game. In a game with more than two players they may not be equal.

[3] This fact requires us to compute data values for other variables by using a weighted average of the calendar month data.

[4] In earlier work we used the cooperative pay price which is the Agrimark "full service" price charged to handlers and includes handling charges for quality control and balancing plus any negotiated premiums. However less than half of the fluid milk sold in the Boston IRI market is supplied by Agrimark. For most of the milk, processors perform on farm quality control and balancing services, thus the Class-I fluid milk price seems to be the most appropriate "farm level milk price". See Dhar and Cotterill (2000) for models that used the cooperative pay price. Results are similar.

[5] We also specified a short run dynamic cost model. In it 1 or 2 month lags and a weighted average of 2 months lagged prices of Class-I milk were specified in addition the current price of milk. The results were not significantly different from the results we present here with only the current price of milk in the model.

since we assume that all changes in raw milk cost are by definition incorporated into marginal costs. $ç_i$ is a parameter that will be estimated.

For our vertical Nash and Stackelberg model, we have two profit functions that need to be maximized. At the retail level we have the following profit function:

$$Đ_i^R = (p_i - w_i)*q_i, \tag{13}$$

and at the processor level:

$$Đ_i^P = (w_i - mc_i)*q_i. \tag{14}$$

For the full Coordination game, the two profit functions become one for the vertically integrated firm. By manipulating the first order conditions derived from the two profit functions we obtain the following estimable first order conditions:

$$\begin{aligned}
p_{SS} &= m + m_{SS} + h_{SS} VPU_{SS} - \left(k \big/ a_1 \right) q_{SS} \\
&\quad + g_{SS} COMP \\
p_{Sh} &= m + m_{Sh} + h_{Sh} VPU_{Sh} - \left(k \big/ b_2 \right) q_{Sh} \\
&\quad + g_{Sh} COMP \\
p_{SM} &= m + m_{SM} + h_{SM} VPU_{SM} - \left(k \big/ c_3 \right) q_{SM} \\
&\quad + g_{SM} COMP \\
p_{DM} &= m + m_{DM} + h_{DM} VPU_{DM} - \left(k \big/ d_4 \right) q_{D} \\
&\quad + g_{DM} COMP.
\end{aligned} \tag{15}$$

Here, when k = 1, then the first order conditions will represent the full coordination game, k = 2 represents first order conditions from vertical Nash game, and k = 3 represents the manufacturer Stackelberg game. The four first order conditions with or without the Compact binary discussed below, and with k = 1, 2 or 3 and the four demand equations are the models that we estimate with nonlinear 3SLS regression using SHAZAM (ver. 8).

The implementation of the North East Dairy Compact near the midpoint of our 32 sample period suggests that we add a binary variable (*COMP*) to the first order conditions. It has value 1 after Compact implementation in July 1997 for two reasons. First, according to neoclassical theory for risk averse firms, when one reduces or eliminates input price risk the margin for both competitive (Turnovsky 1969) and noncompetitive (Azzam 1991) firms unambiguously narrows. One no longer has a risk premium built into the margin. Congress used this fact to conclude that price stabilization via the Compact could raise prices to farmers with a less than commensurate increase in retail prices (Federal Register 1997). If this is the case than the binary variable should have a significant negative coefficient. Alternatively, similar to the ethyl case (Hay 1999) and as suggested by the focal point theorem (Schelling 1960) the implementation of the Compact, a distinct non-market event with considerable opportunity to signal price intentions, may have facilitated collusive pricing by processors and retailers. This predicts a positive impact for the compact binary.

5. Estimation Results

The vertical Nash, vertical Stackelberg and full coordination models were estimated using nonlinear 3SLS.[6] We use the Davidson-Fletcher-Powel algorithm and minimize the error sum of squares in the linear pseudo model. The Vuong (1989) test gave no significant guidance for choosing one model over another. A partial test for the appropriate model is to compare the estimated wholesale to retail price CPTRs against the assumed conjectures in each model. The Stackelberg model fits better than the Vertical Nash. The CPTR from wholesale to retail for Stackelberg conduct are 0.5 and our estimates are closer to 0.5 than the Vertical Nash value 1 (see Table 3, second column). Therefore we will focus on the Stackelberg results in the text. The results for the other two models are quite similar to the Stackelberg and are available from the authors.

Table 2 presents the regression results for the Stackelberg game with and without the Compact binary. We use the Vuong test to distinguish between models with and without the Compact binary. With a chi-square test statistic of 20.15 and 1 degree of freedom, the model with the Compact binary performs better at the 1% significance level. All four own price coefficients in the demand equations are negative and statistically significant at the 5 % level, or higher, in the model with or without the Compact binary. Cross price coefficients generally are positive. More are statistically significant without the Compact binary because it captures the effect of the largest price change in the data set which otherwise helps to identify switching conduct by consumers. Without the Compact binary all chains have at least one significant substitute. For the model with the binary only Stop & Shop has no significant

[6] The descriptive statistics for all the variables are available from the author.

substitute. Generally Shaw's and DeMoulas pricing tend to affect other chains volume more than Stop & Shop and Star Market prices do. In conclusion fluid milk consumers do, to some significant extent, switch their purchases from one chain to another based on price. For products less visible and less frequently purchased than milk one would more likely find less switching between chains, i.e. retail monopoly and lower price transmission.

The estimation results for the cost parameters displayed in Table 2 are robust. Seven of the eight parameters are significant at the 5% or better level and the signs are correct in both models (with and without the Compact binary).

In Table 3 we present the estimated pass-through rates and assorted statistical tests for the Stackelberg game with the Compact binary specified in the model.[7] The pass through rates are presented for each chain, for each stage, and for the total channel. First we examine the impact of an industry wide cost shock (changes in the farm level milk price) and then we will discuss firm specific cost shocks. For each of these chains farm level milk price shocks are almost completely transmitted to the wholesale and retail level. The cost pass through rates vary from 0.878 to 0.999 and all are not significantly different from 1.

Table 3 also presents detailed results for firm specific CPTR. There is clear support for strategic interaction between firms and noncompetitive pricing. All of the firm specific own pass through rates are significantly different from zero at the 5% level or better. Ashenfelter et al. reported a 15% firm specific own pass through rate for Staples, an office superstore chain. As reported in Table 3a we find higher own pass through rates ranging from 0.55 to 0.65 from processor to wholesale and ranging from 0.54 to 0.62 from wholesale to retail.

Lets now examine cross firm price transmission in Table 3. Significant cross shock cost pass through rates range from 0.14 to 0.23 from farm to wholesale from 0.16 to 0.26 and from wholesale to retail. If one is examining cost decreases due to a merger then an added benefit not considered by Ashenfelter et al. in a noncompetitive market place is the price reductions of other firms when the merging firm has unilateral cost savings. Focusing on Stop & Shop and Star Markets note that unilateral cost shocks to their processors and unilateral changes in their wholesale prices have no impact on Shaw's or DeMoulas prices, nor on each other's prices. Stop and Shop and Star Markets seem to be pricing in a vacuum. This clearly is not the case for Shaw's and DeMoulas. Unilateral cost shocks to their processors and unilateral changes in their wholesale prices have positive and significant impacts on Stop & Shop, Star and each other. These asymmetric price interdependencies indicate that processor initiated increases in wholesale prices only to Shaw's and DeMoulas will also increase retail prices at Stop & Shop and Star Market, thereby widening these latter two chain's profit margins.

Turning now to analysis of the industry's response to the North East Dairy Compact program, Table 4 indicates that the farm level milk price averaged \$1.40/gal prior to the NEDC and it was extremely volatile with a standard deviation of \$0.10/gal. In July 1997 the Compact raised the price \$0.06/gal above its expected price level to \$1.46/gallon; however it reduced price variance to zero. Returning now to Table 2 let's examine the impact of the Compact binary variable on retail milk price to see if there was a structural shift in the model. Two opposite impacts are: 1) the elimination of a risk premium and a consequent reduction in the margin or 2) a shift to more collusive pricing with a widening of the margin at the July 1997 focal point. The evidence for each of the chains clearly indicates that margins, ceteris paribus, did not narrow when price risk to the key input was eliminated. To the contrary a shift to a new less competitive pricing regime raised prices nine cents a gallon at Stop & Shop and Shaw's and eleven cents a gallon at Star Market and DeMoulas. These price increases significant at the 10% or 5% level.

We conclude, that between one and two thirds of the price increase at retail that generally has been attributed to North East Dairy Compact gains for farmers went to processors and/or retailers via widened margins.

6. Conclusions

One can advance our understanding of price transmission and strategic pricing by marketing firms through structural modeling. It is possible to decompose, and test cost pass-through rates within the context of explicit strategic games. This is the first research effort to systematically identify and measure differences between the transmission of industry wide and firm specific cost shocks in a structural model. The result is a much more detailed analysis of market channel conduct. Industry wide and firm specific cost shocks are not identical, nor do the latter necessarily aggregate to the former. In a differentiated product

[7] Results without the binary and for the other two games are nearly identical and are available from the authors upon request.

industry one can, as we do here, effectively observe 100% transmission of an industry wide cost shock. In this model this result is a necessary but not sufficient condition for effective competition. If one has nonzero transmission of firm specific cost shocks, then one does not have effective competition.

In this study firm specific pass through rates at wholesale and retail fall generally around 50 percent. For the total channel, firm specific pass through rates are near 25%, the retail monopoly level. Stop & Shop and Star Market seem to enjoy retail monopoly status more than Shaw's and DeMoulas. Stop and Shop is the market leader and Star is the leader in the urban core of the market where most of its stores are located.

Finally we find that our model of vertical strategic interaction benefited from allowing horizontal pricing conduct to shift at Compact implementation. The risk reduction benefit from raw input price stabilization was completely overpowered by a shift towards more complete tacit collusion post-Compact. Margins widened significantly and consequently retail prices went up by more than the raw input price increase. If one includes this shift in conduct in the price transmission model then retail prices went up by more than the 100 percent when the Compact increased raw fluid milk prices.

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Table 1(a): Input Cost to Wholesale and Wholesale to Retail Cost Pass Through Rates: Two Processors and Two Retailers

Cost Pass Through Rate		Vertical Stackelberg		Vertical Nash	
		General	Retail Monopolies[±]	General	Retail Monopolies[±]
1. Effect of Change in the M on W_p of P_1.	$\left.\frac{dw_1}{dm}\right\|_{dm[1]=dm[2]=0}$	$\frac{-2a_2b_2-3a_2b_1+8a_1b_2}{16a_1b_2-9a_2b_1}$	$\frac{1}{2}$	$\frac{6a_1b_2-2a_2b_1-a_2b_2}{9a_1b_2-4a_2b_1}$	$\frac{2}{3}$
2. Effect of Change in the M on W_p of P_2	$\left.\frac{dw_2}{dm}\right\|_{dm[1]=dm[2]=0}$	$\frac{-2a_1b_1-3a_2b_1+8a_1b_2}{16a_1b_2-9a_2b_1}$	$\frac{1}{2}$	$\frac{6a_1b_2-2a_2b_1-a_1b_1}{9a_1b_2-4a_2b_1}$	$\frac{2}{3}$
3. Effect of Change in the FSC of Processor 1 on the W_p of P_1	$\left.\frac{dw_1}{dm_1}\right\|_{dm=dm[2]=0}$	$\frac{8a_1b_2-3a_2b_1}{16a_1b_2-9a_2b_1}$	$\frac{1}{2}$	$\frac{6a_1b_2-2a_2b_1}{9a_1b_2-4a_2b_1}$	$\frac{2}{3}$
4. Effect of Change in the FSC of P_1 on the W_p of P_2	$\left.\frac{dw_2}{dm_1}\right\|_{dm=dm[2]=0}$	$\frac{-2a_1b_1}{16a_1b_2-9a_2b_1}$	0	$\frac{-a_1b_1}{9a_1b_2-4a_2b_1}$	0
5. Effect of Change in the FSC of P_2 on the W_p of P_1	$\left.\frac{dw_1}{dm_2}\right\|_{dm=dm[1]=0}$	$\frac{-2a_2b_2}{16a_1b_2-9a_2b_1}$	0	$\frac{-a_2b_2}{9a_1b_2-4a_2b_1}$	0
6. Effect of Change in the FSC of P_2 on the W_p of P_2	$\left.\frac{dw_2}{dm_2}\right\|_{dm=dm[1]=0}$	$\frac{8a_1b_2-3a_2b_1}{16a_1b_2-9a_2b_1}$	$\frac{1}{2}$	$\frac{6a_1b_2-2a_2b_1}{9a_1b_2-4a_2b_1}$	$\frac{2}{3}$
7. Effect of Change in the W_p of R_1 on the R_p of R_1	$\left.\frac{dp_1}{dw_1}\right\|_{dw[2]=0}$	$\frac{2a_1b_2}{4a_1b_2-a_2b_1}$	$\frac{1}{2}$	$\frac{2a_1b_2}{4a_1b_2-a_2b_1}$	$\frac{1}{2}$
8. Effect of Change in the W_p of R_1 on the R_p of R_1.	$\left.\frac{dp_2}{dw_1}\right\|_{dw[2]=0}$	$\frac{-a_1b_1}{4a_1b_2-a_2b_1}$	0	$\frac{-a_1b_1}{4a_1b_2-a_2b_1}$	0
9. Effect of Change in the W_p of R_2 on the R_p of R_1	$\left.\frac{dp_1}{dw_2}\right\|_{dw[1]=0}$	$\frac{-a_2b_2}{4a_1b_2-a_2b_1}$	0	$\frac{-a_2b_2}{4a_1b_2-a_2b_1}$	0
10. Effect of Change in the W_p of R_2 on the R_p of R_2	$\left.\frac{dp_2}{dw_2}\right\|_{dw[1]=0}$	$\frac{2a_1b_2}{4a_1b_2-a_2b_1}$	$\frac{1}{2}$	$\frac{2a_1b_2}{4a_1b_2-a_2b_1}$	$\frac{1}{2}$

Keys: M: Farm Level Milk Price; W_p: Wholesale Price; R_p: Retail Price; R_1 & R_2: Retailer 1 & 2; P_1 & P_2: Processor 1 & 2; FSC: Firm Specific Cost.

[±] Retail Monopolies case: $a_2 = b_1 = 0$

Table 1(b): CPTR Equations For Two Processors and Two Retailers (Total)

Total CPTR		Vertical Stackelberg		Vertical Nash		Vertical Coordination	
		General	Retail Monopolies[±]	General	Retail Monopolies[±]	General	Retail Monopolies[±]
1. Effect of M Change on R_p of R_1	$\frac{dp_1}{dm}$	$\frac{(4a_1-3a_2)b_2}{16a_1b_2-9a_2b_1}$	$\frac{1}{4}$	$\frac{(3a_1-2a_2)b_2}{9a_1b_2-4a_2b_1}$	$\frac{1}{3}$	$\frac{b_2(2a_1-a_2)}{4a_1b_2-a_2b_1}$	$\frac{1}{2}$
2. Effect of M Change on R_p of R_2	$\frac{dp_2}{dm}$	$\frac{(4b_2-3b_1)a_1}{16a_1b_2-9a_2b_1}$	$\frac{1}{4}$	$\frac{(3b_2-2b_1)a_1}{9a_1b_2-4a_2b_1}$	$\frac{1}{3}$	$\frac{a_1(2b_2-b_1)}{4a_1b_2-a_2b_1}$	$\frac{1}{2}$
3. Effect of P_1 Specific FSC Change on R_p of R_1	$\frac{dp_1}{dm_1}$	$\frac{4a_1b_2}{16a_1b_2-9a_2b_1}$	$\frac{1}{4}$	$\frac{3a_1b_2}{9a_1b_2-4a_2b_1}$	$\frac{1}{3}$	$\frac{2a_1b_2}{4a_1b_2-a_2b_1}$	$\frac{1}{2}$
4. Effect of P_1 Specific FSC Change on R_p of R_2	$\frac{dp_2}{dm_1}$	$\frac{-3a_1b_1}{16a_1b_2-9a_2b_1}$	0	$\frac{-2a_1b_1}{9a_1b_2-4a_2b_1}$	0	$\frac{-a_1b_1}{4a_1b_2-a_2b_1}$	0
5. Effect of P_2 Specific FSC Change on R_p of R_1	$\frac{dp_1}{dm_2}$	$\frac{-3a_2b_2}{16a_1b_2-9a_2b_1}$	0	$\frac{-2a_2b_2}{9a_1b_2-4a_2b_1}$	0	$\frac{-a_2b_2}{4a_1b_2-a_2b_1}$	0
6. Effect of P_2 Specific FSC Change on R_p of R_2	$\frac{dp_2}{dm_2}$	$\frac{4a_1b_2}{16a_1b_2-9a_2b_1}$	$\frac{1}{4}$	$\frac{3a_1b_2}{9a_1b_2-4a_2b_1}$	$\frac{1}{3}$	$\frac{2a_1b_2}{4a_1b_2-a_2b_1}$	$\frac{1}{2}$

Keys: M: Farm Level Milk Price; W_p: Wholesale Price; R_p: Retail Price; R_1 & R_2: Retailer 1 & 2; P_1 & P_2: Processor 1 & 2; FSC: Firm Specific Cost.

[±] Retail Monopolies case: $a_2 = b_1 = 0$

Table 2: Estimation Results - from Manufacturer Stackelberg Game

Variable Name	Without Compact Binary Estimate	Without Compact Binary Asymptotic t-Statistic	With Compact Binary Estimate	With Compact Binary Asymptotic t-Statistic
Demand Parameters for Stop & Shop:				
Intercept I1	0.72377	0.3710	0.14077	0.0472
Own Price A1	-0.010044	-4.542***	-0.0082753	-2.2064**
Shaw's Price A2	0.005541	3.0291***	0.0029295	1.3479
Star Market Price A3	-0.0010398	-0.3360	0.00078195	0.2066
DeMoulas Price A4	0.0064445	2.1243**	0.0055082	1.5072
Weighted Average % Price Reduction A5	0.01422	1.0756	0.0041583	0.2817
Demand Parameters for Shaw's:				
Intercept I2	2.9004	1.7235	3.5549	1.6983*
Stop & Shop Price B1	0.0022435	0.6721	-0.0002705	-0.0761
Own Price B2	-0.011126	-6.2359***	-0.0088915	-5.4696***
Star Market Price B3	0.001991	0.8299	0.0013445	0.4866
DeMoulas Price B4	0.0063856	2.735**	0.0071794	2.8218***
Weighted Average % Price Reduction B5	0.0096614	1.6158	0.014592	2.5574**
Demand Parameters for Star Market:				
Intercept I3	4.6104	3.8746***	2.4383	0.6782
Stop & Shop Price C1	0.0032171	1.8228*	0.0018919	0.7239
Shaw's Price C2	0.0036738	3.6158***	0.0045446	3.2675***
Own Price C3	-0.011365	-7.1282***	-0.012235	-5.4113***
DeMoulas Price C4	0.0039465	2.2253**	0.0064194	2.3101**
Weighted Average % Price Reduction C5	-0.0022409	-0.4067	-0.0023167	-0.3672
Demand Parameters for DeMoulas:				
Intercpet I4	1.7971	1.4841	0.30257	0.2314
Stop & Shop Price D1	0.0056188	2.0169**	0.0030522	1.2752
Shaw's Price D2	0.0024684	1.8059*	0.0047384	4.8193***
Star Market Price D3	0.0018051	0.7683	0.0028574	1.4516
Own Price D4	-0.011396	-6.0982***	-0.011583	-7.4859***
Weighted Average % Price Reduction D5	0.0011866	0.2522	-0.0012751	-0.3409
Cost Parameters Stop & Shop:				
Intercpet CI1	1.5316	4.8102***	1.6298	2.4098**
Voume Per Unit M1	-1.1156	-2.3054**	-1.4281	-1.2896
Compact Dummy k1			0.08927	1.7183*
Cost Parameters for Shaw's:				
Intercept CI2	1.5558	5.3381***	1.6588	5.3968***
Volume Per Unit M2	-1.0371	-2.6068**	-1.328	-2.8785***
Compact Dummy k2			0.088574	1.7691*
Cost Parameters for Star Market:				
Intercept CI3	1.222	4.9846***	1.3335	4.3285***
Volume Per Unit M3	-0.19848	-0.8574	-0.42533	-1.0162
Compact Dummy k3			0.11022	1.7869*
Cost Parameters for DeMoulas:				
Intercept CI4	1.35	4.5265***	1.1439	5.1803***
Volume Per Unit M4	-0.94315	-2.3198***	-0.72148	-2.4806**
Compact Dummy k4			0.10586	2.2481**

* LOG-LIKELIHOOD FUNCTION= -155.01728 With Compact Dummy and -155.44992 Without Compact Dummy

Significance Level as Superscript of the t-statistic: * - 10%; ** - 5%; *** - 1%

Table 3: Cost Pass Through (CPTR) Table - Vertical Stackelberg Game

Stop & Shop					
Input Cost to Wholesale Price: Change in the Wholesale Price of Stop & Shop		Wholesale price to Retail Price: Change in the Retail Price of Star Market		Total: Stop & Shop	
	CPTR		CPTR		CPTR
Milk Price Shock H_0: CPTR = 1.0[1]	0.999			Milk Price Shock H_0: CPTR = 1.0[1]	0.998
Firm Specific Shock				Firm Specific Shock	
Own H_0: CPTR = 0.5[2]	0.550	Own H_0: CPTR = 0.5[2]	0.538	Own H_0: CPTR = 0.25[2]	0.325
Cross Shock from: Shaw's Processor	0.148 (***)	Cross Shock from: Shaw's Wholesale Price Change	0.162 (***)	From Shaw's: Processor	0.222 (***)
Cross Shock from: Star Market's Processor	0.074	Cross Shock from: Star Market's Wholesale Price Change	0.070	From Star Market's: Processor	0.111
Cross Shock from: DeMoulas's Processor	0.227 (***)	Cross Shock from: DeMoulas's Wholesale Price Change	0.263 (***)	From DeMoulas's Processor	0.340 (***)

Shaw's					
Input Cost to Wholesale Price: Change in the Wholesale Price of Shaw's		Wholesale price to Retail Price: Change in the Retail Price of Shaw's		Total: Shaw's	
	CPTR		CPTR		CPTR
Milk Price Shock H_0: CPTR = 1.0[1]	0.919			Milk Price H_0: CPTR = 1.0[1]	0.878
Firm Specific Shock				Firm Specific Shock	
Own H_0: CPTR = 0.5[2]	0.595 (***)	Own H_0: CPTR = (0.5)[2]	0.574 (***)	Own H_0: CPTR = 0.25[2]	0.393 (***)
Cross Shock from: Stop & Shop's Processor	0.044	Cross Shock from: Stop & Shop's Wholesale Price Change	0.032	From Stop & Shop's: Processor	0.065
Cross Shock from: Star Market's Processor	0.071	Cross Shock from: Star Market' Wholesale Price Change	0.077	From Star Market's: Processor	0.107
Cross Shock from: DeMoulas's Processor	0.209 (***)	Cross Shock from: DeMoulas's Wholesale Price Change	0.262 (***)	From DeMoulas's Processor	0.313 (***)

(*continues*)

Level of Significance: (***) - 1%; (**) - 5%; (*) - 10% Based on Wald Chi-Square Test Statistic

[1]Null hypothesis based on strong substitute case; [2]Null hypothesis based on monopoly case; rest of the est. CPTR tested against 0.

Table 3 (*continued*)

Star Market					
Input Cost to Wholesale Price: Change in the Wholesale Price of Star Market	CPTR	Wholesale price to Retail Price: Change in the Retail Price of Star Market	CPTR	Total: Star Market	CPTR
Milk Price Shock H_0: CPTR = 1.0[1]	0.975			Milk Price Shock H_0: CPTR = 1.0[1]	0.963
Firm Specific Shock				Firm Specific Shock	
Own H_0: CPTR = 0.5[2]	0.559	Own H_0: CPTR = 0.5[2]	0.544	Own H_0: CPTR = 0.25[2]	0.339
Cross Shock from: Stop & Shop's Processor	0.064	Cross Shock from: Stop & Shop's Wholesale Price Change	0.070	From Stop & Shop's: Processor	0.096
Cross Shock from: Shaw's Processor	0.144 (***)	Cross Shock from: Shaw's Wholesale Price Change	0.161 (***)	From Shaw's: Processor	0.216 (***)
Cross Shock from: DeMoulas's Processor	0.208 (***)	Cross Shock from: DeMoulas's Wholesale Price Change	0.231 (***)	From DeMoulas's Processor	0.312 (***)

DeMoulas					
Input Cost to Wholesale Price: Change in the Wholesale Price of DeMoulas	CPTR	Wholesale price to Retail Price: Change in the Retail Price of DeMoulas	CPTR	Total: DeMoulas	CPTR
Milk Price Shock H_0: CPTR = 1.0[1]	0.930			Milk Price H_0: CPTR = 1.0[1]	0.895
Firm Specific Shock				Firm Specific Shock	
Own H_0: CPTR = 0.5[2]	0.647 (***)	Own H_0: CPTR = (0.5)[2]	0.617 (***)	Own H_0: CPTR = 0.25[2]	0.471
Cross Shock from: Stop & Shop's Processor	0.068	Cross Shock from: Stop & Shop's Wholesale Price Change	0.086	From Stop & Shop's: Processor	0.102
Cross Shock from: Shaw's Processor	0.136 (***)	Cross Shock from: Shaws' Wholesale Price Change	0.158 (***)	From Shaw's: Processor	0.204 (***)
Cross Shock from: Star Market's Processor	0.078	Cross Shock from: Star Market's Wholesale Price Change	0.092	From Star Market's Processor	0.118

Level of Significance: (***) - 1%; (**) - 5%; (*) - 10% Based on Wald Chi-Square Test Statistic

[1]Null hypothesis based on strong substitute case; [2]Null hypothesis based on monopoly case; rest of the est. CPTR tested against 0.

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