The Theory of Price Collars: The Linking of Prices in a Market Channel to Redress the Exercise of Market Power

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I. Introduction

The marketing channels for many goods involve the production of a raw commodity that is processed and then distributed to retailers for sale to consumers. Either the processing industry or the retailing industry or both may exercise substantial market power ultimately against raw commodity suppliers or consumers, the disorganized (competitive) economic groups at the ends of the market channel. This paper develops a theory of price collars to regulate pricing in such a channel. Price collars link raw product, wholesale and retail prices but do not explicitly set such prices. For example, a wholesale price collar could limit the wholesale price to 140% of the raw commodity price, and a retail price collar could limit retail price to 130% of the wholesale price.

Note that this policy has 2 instruments that address three prices. Thus the policy cannot set these prices. This is by design. The policy seeks to preserve a modicum of firm pricing authority to allow firms to react to cost and demand shifts in the industries. Our theory analyzes what retail, wholesale and raw commodity prices would be in a post-regulation equilibrium assuming firms maximize profits. We derive the conditions that must be satisfied to generate an increase or decrease in each of the three prices in the marketing channel, and show how equilibrium prices change when a regulatory agency alters the price collars. Although the agency does not set prices it can manage prices to attain desired policy targets.

This paper is organized as follows: section I is introduction, section II analyzes post-regulation retail pricing and the implication of retail price leadership for wholesale and raw product prices. Since wholesale and raw product prices are linked by price collars, we show that retailers also determine those prices when setting retail prices. We derive the qualitative conditions that are necessary for post-regulation retail, wholesale and raw prices to be higher, the same, or lower than pre-regulation prices and the formulas for post-regulation equilibrium prices.

Section III analyzes post-regulation wholesale pricing and the implication of wholesale price leadership for retail and raw product prices. As in the retail pricing section the regulation links wholesale pricing moves to retail and raw prices. We also derive the formulas for post-regulation equilibrium prices and qualitative analysis of the difference between pre-and post-regulation prices.

Section IV recognizes the retailer's and processor's profit maximizing moves under regulation generate different desired equilibrium price vectors. We suggest that under regulation retailers and processors must bargain and that the resulting equilibrium prices will depend on the relative bargaining power of retailers and processors.

Section V applies the theory to the fluid milk market in New England where there is documented market power and excessive margins at the retail. Retailers clearly dominate the market channel, and our analysis documents that dominance. The intent of a proposed milk price collar policy in Connecticut is to reduce retail margins by increasing raw (farm) milk prices and reducing retail prices. Nonetheless the regulatory regime would permit firms to cover their costs and earn profits, but profits more in line with a competitive rate of return. Section VI concludes the paper.

II. Pre- and Post-Regulation Prices with Retailer Price Leadership under Regulation

Following Slade (1995) and others we initially assume that each retail firm has a monopoly based upon geographic location and product differentiation, i.e. the firm's demand curve for the processed product under analysis is downward sloping. We will relax this assumption to analyze retail oligopoly pricing of differentiated products. We assume that a supermarket chain applies category management techniques, i.e. it seeks to maximize the joint profit of all brands it sells in this category; and we assume that the retail price collar applies to all brands in the processed product category.

Finally we need specify the nature of vertical competition with processors. Essentially we assume that retailers regard the wholesale milk prices as a parameter when maximizing profits. This may be due to one of two possibilities. Processing may be effectively competitive with a flat supply curve or retailers may play a vertical Nash game, i.e. maintain that their pricing moves have no effect on a processing oligopoly that feed back through changes in wholesale price to alter their pricing strategies.

Before the regulation is implemented, a monopoly retailer solves the following profit-maximizing problem:

(1) $$\max_{p_i} \pi_i^R = \sum_{i=1}^{n} (p_i^B - w_i^B - c_i) q_i^B$$

where c_i = the non-milk in-store marginal costs of retailing the product i

w_i^B = the wholesale price of the processed product i before the regulation

p_i^B = the retail price of the processed product i before the regulation

q_i^B = the demand curve as a function of p_i^B

The solution to the monopoly retailer's profit maximization problem is:

(2) $$P^B = \Omega^{B^{-1}} \Sigma^B (W^B + C)$$

where $C = [c_i \quad \ldots \quad c_k]'$

$$\Omega^B = \begin{bmatrix} s_1^B(1+\varepsilon_{11}^B) & \dots & s_n^B\varepsilon_{1n}^B \\ \dots & \dots & \dots \\ s_1^B\varepsilon_{n1}^B & \dots & s_n^B(1+\varepsilon_{nn}^B) \end{bmatrix}$$

$$\Sigma^B = \begin{bmatrix} s_1^B\varepsilon_{11}^B & \dots & s_n^B\varepsilon_{1n}^B \\ \dots & \dots & \dots \\ s_1^B\varepsilon_{n1}^B & \dots & s_n^B\varepsilon_{nn}^B \end{bmatrix}$$

$s_i^B = \dfrac{q_i^B}{Q}$; Q is the total quantity for the entire market

$$\varepsilon_{ji}^B = \frac{\partial q_j^B}{\partial p_i^B}\frac{p_i^B}{q_j^B}$$

After a price collar policy is implemented, the retail price collar, k, is binding because the policy goal is to lower retail price. A monopoly retailer's profit maximization problem is now different. Define a new vector of prices $p_i^N = (1-\frac{1}{k})p_i = p_i^B - w_i^B$. Now the firm's retail profit maximization problem can be restated in p_i^N as follows:

(3) $$\max_{p_i^N}\pi_i = \sum_{i=1}^{n}(p_i^N - c_i)q_i$$

where $p_i^N = \dfrac{k-1}{k}p_i$. The solution to this new problem when p_i^N is the new choice variable is:

(4) $$P^N = \Omega^{-1}\Sigma C$$

where $P^N = [p_i^N \quad \dots \quad p_n^N]'$

$$\Omega = \begin{bmatrix} s_1(1+\varepsilon_{11}^N) & \dots & s_n\varepsilon_{1n}^N \\ \dots & \dots & \dots \\ s_1\varepsilon_{n1}^N & \dots & s_n(1+\varepsilon_{nn}^N) \end{bmatrix}$$

$$\Sigma = \begin{bmatrix} s_1\varepsilon_{11}^N & \dots & s_k\varepsilon_{1n}^N \\ \dots & \dots & \dots \\ s_1\varepsilon_{n1}^N & \dots & s_n\varepsilon_{nn}^N \end{bmatrix}$$

$s_i = \frac{q_i}{Q}$; Q is the total quantity for the entire market

$$\varepsilon_{ji}^N = \frac{\partial q_j}{\partial p_i^N}\frac{p_i^N}{q_j}$$

After substituting $p_i^N = \frac{k-1}{k}p_i$ for i = 1, …, n, equation (4) becomes:

(5) $$P = \frac{k}{k-1}\Omega^{-1}\Sigma C$$

The difference between the post-regulation and pre-regulation retail prices is equation (5) minus equation (2):

(6) $$P - P^B = \frac{k}{k-1}\Omega^{-1}\Sigma C - \Omega^{B^{-1}}\Sigma^B(W^B + C)$$

If there is no change in any of the retail prices, the following condition holds:

(7) $$\varepsilon_{ij}^N = \frac{\partial Q_i}{\partial P_j^N}\frac{P_j^N}{Q_i} = \frac{\partial Q_i}{\partial P_j}\frac{\partial P_j}{\partial P_j^N}\frac{k-1}{k}\frac{P_j}{Q_i} = \frac{\partial Q_i}{\partial P_j}\frac{k}{k-1}\frac{k-1}{k}\frac{P_j}{Q_i} = \frac{\partial Q_i}{\partial P_j}\frac{P_j}{Q_i} = \varepsilon_{ij}^B$$

Equation (7) indicates that if the retail prices before and after regulation are equal, then the own and cross demand elasticities before and after will also be the same. Equating (6) to 0 and substituting (7) into it gives:

(8) $$C = (k-1)W^B$$

Equation (8) can be met only if

(9) $$\frac{c_i}{w_i^B} = k-1$$

for all products, i = 1, …, n. If $\frac{c_i}{w_i^B} > k-1$, post-regulation retail price is higher. If $\frac{c_i}{w_i^B} < k-1$, post-regulation retail price is lower.

Given that retailers honor the constraint p = kw, the wholesale price and raw milk price after the regulation is implemented is:

$$(10) \qquad W = \frac{1}{k-1}\Omega^{-1}\Sigma C$$

Assuming the pre-regulation ratio of wholesale and raw price is greater than m, if $w_i \geq w_i^B$, then the post-regulation raw price is also higher. Since processors honor the second price collar, i.e. w = mr, the raw product price under the retailer leadership case is:

$$(11) \qquad R = \frac{1}{m(k-1)}\Omega^{-1}\Sigma C$$

If one has estimated values of in-store marginal cost and supermarket own price elasticities of demand then one can simulate the post-regulation equilibrium prices and compare them to pre-regulation equilibrium prices.

II.1 Generalization to Retail Oligopoly

A more general model of competition among supermarkets chains for shoppers explicitly incorporates cross–chain substitubility for retail product purchases. We illustrate the implication of the regulation with the oligopoly case. Assuming general demand function for differentiated products, a retailer's profit maximization problem is defined as in equation (1). The only difference is that the number of brands, n, expands to all brands at different retailers. Assuming Nash Bertrand pricing among all retailers, we get the following solution for retailer j:

$$(13) \qquad P_j^B = \Omega_j^{B^{-1}}\Sigma_j^B(W_j^B + C_j)$$

All vectors include the prices and costs only related to retailer j and the matrices include own price demand elasticities and cross price demand elasticities for retailer j and all other retailers in the market. Note that the solution is the same as in the retail monopoly case and thus results in the same impact equations as (8) and (9). This completes the proof of the desired impact equation in the case of Nash Bertrand oligopoly at retail.

We may be able to rule out the case of collusive retail pricing before regulation in industries that process food products. Virtually all market research on the market level price elasticity of demand for food products finds inelastic demands. If fully collusive pricing existed among sellers they would elevate prices to the elastic portion of each market demand curve. Since that has not happened, the Nash–Bertrand model seems more appropriate. After regulation the fact that retailers must honor the price collar limits their ability to collude.

III. Pre- and Post-Regulation Prices with Wholesaler Price Leadership under Regulation

A processor's best response given that the retailer complies with the retail price collar may be different than the prior analysis of a retailer's best response given that processors comply with the wholesale price collar. There are at least two ways one can analyze the processor's profit maximization problem. First is a very general approach to vertical organization of the market channel. Assume that a wholesale demand function exists and has negative slope. This derived demand curve depends on retail demand and some unspecified but stable retailer conduct that allows a processor to measure its wholesale demand schedule. In this case one has exactly the same problem as was solved at retail, a general demand function, a fixed raw input price, and alternative processor market structures: processor monopoly and oligopoly. The results of the last section apply to processing.

Alternatively one can specify a particular vertical game and derive some additional information about retail pricing because one then knows how retail and derived wholesale demand are related. Here we assume vertical Nash competition with its assumptions that $\frac{\partial p_i}{\partial w_i} = 1$ and $\frac{\partial p_i}{\partial w_j} = 0$ (Choi, 1991). We present the results for this approach to the processor leadership profit maximization problem and use them in our simulation analysis. Again we stress that the basic results are the same as the symmetric-to-retail approach, but one has an additional condition related to retail prices in this more tightly specified model.

Under regulation retailers' compliance with the retail price collar gives the following derived inverse demand for a processor:

$$(14) \qquad w_i(q_i) = \frac{p(q)}{k};$$

where q is a vector of demands for all products in the market. Given this demand specification we assume that each processor supplies only one brand and solves the following profit-maximization problem:

$$(15) \qquad \max_{w_i^N} \pi_i^m = (w_i^N - mc_i)q_i$$

where $w_i^N = \frac{m-1}{m} - w_i$ and mc_i is the non-raw-commodity marginal cost in producing product i. We assume all producers pay the same raw commodity price. The solution to this post-regulation problem is:

$$(16) \qquad w_i = \frac{m}{m-1}\frac{\varepsilon_i}{1+\varepsilon_i}mc_i$$

where ε_i is the elasticity of demand at both wholesale and retail since they are related proportionally in (14).

As we know the retailer must comply with the price collar at retail given a pre-determined wholesale price, the retail price for product i thus must be:

$$(17) \qquad p_i = \frac{km}{m-1}\frac{\varepsilon_i}{1+\varepsilon_i}mc_i$$

Now let's state the solution to the processor's pre-regulation profit maximization problem:

$$(18) \qquad w_i^B = \frac{\varepsilon_i^B}{1+\varepsilon_i^B}(r^B + mc_i) - \frac{1}{1+\varepsilon_i^B}g_i^B$$

where ε_i^B is the pre-regulation own demand elasticity for processor i, r^B is pre-regulation raw price, mc_i is the processor i's marginal cost, and g_i^B is the profit maximizing gross margin at retail. Adding the retail gross margin to equation (18) gives the pre-regulation profit maximizing retail price:

$$(19) \qquad p_i^B = w_i^B + g_i^B = \frac{\varepsilon_i^B}{1+\varepsilon_i^B}(r^B + mc_i) + \frac{\varepsilon_i^B}{1+\varepsilon_i^B}g_i^B$$

In order to examine how wholesale price would change after regulation one needs to consider the pre- and post-regulation retail prices and corresponding retail demand elasticities. So let's first examine the condition for the change in post-regulation retail price. Subtracting equation (19) from (17) gives:

$$(20) \qquad p_i - p_i^B = \frac{km}{m-1}\frac{\varepsilon_i}{1+\varepsilon_i}mc_i - \frac{\varepsilon_i^B}{1+\varepsilon_i^B}(r^B + mc_i) - \frac{\varepsilon_i^B}{1+\varepsilon_i^B}g_i^B$$

If there is no change in post-regulation retail price of brand i, then equation (20) is zero and becomes the following after simplification:

$$(21) \qquad \frac{km}{m-1}mc_i = r^B + mc_i + g_i^B \qquad \text{or} \qquad \frac{km}{m-1}mc_i = r^B + mc_i + p_i^B - w_i^B$$

The post-regulation retail price is lower if equation (22) holds:

$$(22) \qquad \frac{km}{m-1} mc_i < r^B + mc_i + p_i^B - w_i^B$$

If one knows the pre-regulation prices, processor marginal cost and the price collar values one can determine whether post-regulation retail prices are equal or lower. If they are not and the processor dominates the bargaining situation then one needs to change k and/or m to ensure that they are, because after all the intent of the proposed regulatory policy is not to elevate retail prices.

For the evaluation of post-regulation wholesale prices when $p_i < p_i^B$, one rewrites equation (16) and (18) based on their corresponding first order conditions:

$$(23) \qquad w_i = \frac{m}{m-1} \frac{ke_i}{1+ke_i} mc_i$$

$$(24) \qquad w_i^B = \frac{e_i^B}{1+e_i^B} (r^B + mc_i)$$

where $e_i = \frac{\partial q_i}{\partial p_i} \frac{w_i}{q_i}$ and $e_i^B = \frac{\partial q_i^B}{\partial p_i^B} \frac{w_i^B}{q_i^B}$. The difference between equation (23) and (24) gives:

$$(25) \qquad w_i - w_i^B = \frac{m}{m-1} \frac{ke_i}{1+ke_i} mc_i - \frac{e_i^B}{1+e_i^B} (r^B + mc_i)$$

Setting equation (25) to zero gives:

$$(26) \qquad \frac{m}{m-1} mc_i - \frac{e_i^B}{1+e_i^B} \frac{1+ke_i}{ke_i} (r^B + mc_i) = 0$$

If $w_i - w_i^B = 0$ or $w_i = w_i^B$, then $e_i > e_i^B$ [1] or $\frac{e_i^B}{1+e_i^B}\frac{1+ke_i}{ke_i} < 1$.

Suppose there exists a range, $w^B < w < \overline{w}$, such that $\frac{e_i^B}{1+e_i^B}\frac{1+ke_i}{ke_i} \leq 1$ where $\overline{w}$ is the point where $\frac{e_i^B}{1+e_i^B}\frac{1+ke_i}{ke_i} = 1$. As a result, $r^B + mc_i \geq \frac{e_i^B}{1+e_i^B}\frac{1+ke_i}{ke_i}(r^B + mc_i)$. If we assume $\frac{m}{m-1}mc_i \geq (r^B + mc_i)$, i.e.

(27) $\frac{mc_i}{r^B} > m - 1$

then it must be true that $\frac{m}{m-1}mc_i \geq \frac{e_i^B}{1+e_i^B}\frac{1+ke_i}{ke_i}(r^B + mc_i)$, i.e. $w^B < w < \overline{w}$ because $r^B + mc_i \geq \frac{e_i^B}{1+e_i^B}\frac{1+ke_i}{ke_i}(r^B + mc_i)$. Equation (27) is sufficient to evaluate $w^B < w < \overline{w}$.

If $w > \overline{w} > w^B$, then $\frac{e_i^B}{1+e_i^B}\frac{1+ke_i}{ke_i} > 1$ [2]. By assumption of $w_i > w_i^B$, $\frac{m}{m-1}mc_i$ must be greater than $\frac{e_i^B}{1+e_i^B}\frac{1+ke_i}{ke_i}(r^B + mc_i)$ and must be greater than $r^B + mc_i$

$\frac{e_i^B}{1+e_i^B}\frac{1+ke_i}{ke_i}(r^B + mc_i) > r^B + mc_i$, which again leads to equation (27).

[1] For $p_i < p_i^B$, $\frac{\partial q_i}{\partial p_i} \geq \frac{\partial q_i^B}{\partial p_i^B}$ ($\frac{\partial q_i}{\partial p_i} \leq \frac{\partial q_i^B}{\partial p_i^B}$ in absolute value) and $q_i > q_i^B$. Therefore, $\frac{\partial q_i}{\partial p_i}\frac{w_i}{q_i} > \frac{\partial q_i^B}{\partial p_i^B}\frac{w_i^B}{q_i^B}$, i.e. $e_i > e_i^B$.

[2] $\frac{e_i^B}{1+e_i^B}\frac{1+ke_i}{ke_i} > 1$ holds only when $w > w^B$ also holds.

This proves that equation (27) is sufficient to determine whether $w_i > w_i^B$ [3]. If retail prices are lower post regulation and equation (27) holds one has higher wholesale prices post regulation.

Raw commodity price is higher after the regulation if $w_i > w_i^B$ and $\frac{w_i^B}{r_i^B} > m$. The other case, $w_i > w_i^B$ and $\frac{w_i^B}{r_i^B} < m$, will be ruled out because the policy goal is to raise raw price and thus $\frac{w_i^B}{r_i^B} > m$ is assumed.

The general procedure for evaluating whether the post-regulation wholesale price is higher or lower in the context of processor pricing leadership is as follows. First one needs to use equation (22) to determine whether the post-regulation retail price is higher than, lower than, or equal to the pre-regulation retail price. Then for each case, one uses equation (27) to determine whether the post-regulation wholesale price is higher or lower than the pre-regulation wholesale price.

IV. Post-Regulation Equilibrium

Before regulation the industry is in equilibrium with unique retail, wholesale and raw commodity prices. There is only one equilibrium given consumer preferences and industry cost structures. This may not be the case after the regulation. One equilibrium only exists when the pre- and post-regulation retail, wholesale and raw prices set by retailers and manufacturers coincide,

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[3] $e_i > e_i^B$ and $\frac{e_i^B}{1+e_i^B}\frac{1+ke_i}{ke_i} < 1$ for all $w_i < w_i^B$. Therefore, if $\frac{m}{m-1}mc_i < \frac{e_i^B}{1+e_i^B}\frac{1+ke_i}{ke_i}(r^B + mc_i)$, i.e. $w_i < w_i^B$, then $\frac{m}{m-1}mc_i < (r^B + mc_i)$ or $\frac{mc_i}{r^B} < m-1$ is not sufficient to evaluate $w_i < w_i^B$.

which is unlikely. Retailers and manufacturers most likely will need to engage in some type of bargaining to find an equilibrium after the regulation.

The bargained equilibrium will lie within intervals: $p^L < p^* < p^H$ and $w^L < w^* < w^H$, $r^L < r^* < r^H$ where the superscripts L and H stand for high and low and * stands for the post-regulation bargained equilibrium. The bounds in these intervals are set by the retailer and processor solutions of the prior two sections. Either the retailer or processor will prefer the high price vector and the other will prefer the low price vector. If either a retailer or processor is dominant in the market channel, the equilibrium will be closer to its end of the range of possible price vectors.

V. Application of the Model to the Southern New England Milk Market

The general theory of price collars can serve any regulatory agency that seeks to restructure raw, wholesale, and retail prices in a commodity marketing channel for any reason. In this section we apply the theory to a non-competitive marketing channel. Research on the milk channel in southern New England gives retail, wholesale and raw milk price and processor marginal cost (Cotterill, 2003). Data are available for each of the major brands for each supermarket chain; however in this paper we will analyze the aggregate of "all milk" data for the representative supermarket and processor to illustrate the theory.

Farmers received $1 per gallon for fluid milk, processing marginal cost was 45 cents per gallon and processors' gross margin was 60 cents for a wholesale price of $1.60. This gross margin is effectively marginal cost plus a competitive return to overhead. The retail price was $3.10 per gallon.[4] Moreover Criner has estimated for the Maine Milk Commission that the in-

[4] Prices are rounded to the nearest dime in this illustrative example.

store marginal cost for supermarkets is 20 cents (Maine Milk Commission). Others estimate that a full cost measure, i.e. also covering fixed overhead for supermarkets is 33 to 44 cents per gallon (Huff, 4/17/03, p.23) and 40 cents per gallon (PMMB, p.17). This means that the net profit margin in southern New England supermarkets is approximately $1.10 per gallon. This is an excessive rate of return that has triggered investigation by the Connecticut Attorney General, legislative hearings in Connecticut and Massachusetts and calls for milk price regulation including price collar regulation[5].

In Connecticut the proposed price collar law would allow a milk regulation board to set price collars. To date the debate has centered on a $k = 1.3$ retail price collar and a $m = 1.4$ wholesale price collar.[6] The intent of these price collars is to raise raw (farm) fluid milk prices and cut retail fluid milk prices to reduce the excessive retail margin without forcing losses on either retailers or processors. To determine whether the collars will do so and to explore how changes in the price collar values influence equilibrium prices we start by analyzing the retailer and processor leadership models. First we will check the qualitative results to see if post regulation retail prices are lower, and wholesale and process prices are higher in the retailer and processor leadership models. Then we will simulate the post-regulation price vector for each model, evaluate the bargaining solution, and determine how the final price solution vector changes when the Board changes price collar values. This exercise illustrates how the Board can attain desired target price outcomes.

For the retail leadership model the retail-pricing rule (9) predicts that if the non-milk marginal cost per gallon of selling milk is less than 30% of the pre-regulation wholesale price ($1.63), i.e. less than 48 cents, then retail price will drop. It is approximately 40-45 cents per

[5] See our website http://www.fmpc.uconn.edu. Click on Milk Price Gouging for documentation.
[6] See Richard Blumenthal, Connecticut Attorney General, letter to Representative George Wilber, dated January 26, 2004 and the attached draft law http://www.fmpc.uconn.edu. Click on Milk Price Gouging.

gallon so retail price is predicted to decline. Since $\frac{p_i^B}{w_i^B} > 1.3$ wholesale prices are higher, and

since

$\frac{w_i^B}{r^B} > 1.4$ raw prices are also predicted to be higher. Given industry cost and pre-regulation

price conditions under retailer leadership model the proposed price collars do move prices in desired or targeted directions.

For the wholesale price leadership model equation (22) in fact holds for we have:

$$\frac{km}{m-1}mc_i = \frac{1.3*1.4}{0.4}0.45 < 1.00 + 0.45 + 3.10 - 1.60 = r^B + mc_i + p_i^B - w_i^B$$

or $2.0475 < 2.95$

This implies that in the processor leadership case retail price will also decline. The relevant condition to determine how wholesale price will change given retail prices declines is equation (27):

$$\frac{mc_i}{r^B} = \frac{0.45}{1.00} < \text{or} > 0.4 = m - 1$$

and one has 0.45 > 0.4. Therefore post-regulation wholesale prices are higher than pre-regulation prices and since:

$$\frac{w_i^B}{r^B} = \frac{1.60}{1.4} > 1.40$$

also holds, raw prices are also higher. In conclusion under the processor leadership model the proposed price collar also move the prices in the desired or targeted direction. Turning now to the simulation results for the retailer leadership model. The pricing rule for simulating the retail price of a single product is:

$$p = \frac{k}{k-1}\frac{\varepsilon}{1+\varepsilon}c$$

where ε is own demand elasticity and c is in-store marginal cost for a retailer.

Table 1: Pre-Regulation Prices and Simulated Post-Regulation Retail, Wholesale, and Raw Milk Prices in the Retailer Leadership Model (Given k = 1.3, c = 0.45)

Own Price Demand Elasticity	Post-Regulation Retail Price	Post-Regulation Wholesale Price	Post-Regulation Raw Price
4.30	2.54	1.95	1.40
4.10	2.58	1.98	1.42
3.90	2.62	2.02	1.44
3.70	2.67	2.06	1.47
3.50	2.73	2.10	1.50
3.30	2.80	2.15	1.54
3.10	2.88	2.21	1.58
3.04*	2.91	2.24	1.60
3.00	2.93	2.25	1.61
2.80	3.03	2.33	1.67
2.60	3.17	2.44	1.74
Pre-Regulation Prices	3.10	1.60	1.00

* Implied demand elasticity at retailing marginal cost of 45 cents.

Table 1 illustrates the post-regulation simulation for different levels of implied own price elasticity and the 1.3 retail price collar and the estimated 45-cent marginal cost for supermarkets. The range of the own price elasticities brackets the elasticity, 3.04, that one obtains by solving $p = \frac{\varepsilon}{1+\varepsilon}(w+c)$ for ε with current observations of average retail and wholesale milk prices and estimated in-store retailing marginal cost. In Table 1 at the average elasticity, 3.04, retail price drops from \$3.10 to \$2.91 and wholesale price increases from \$1.60 to \$2.24 per gallon. Retail gross margin is reduced from \$1.50 to 67 cents, which covers the retailer's estimated full cost of 45 cents and leaves 22 cents net profit. The processor receives \$2.24 and pays farmers \$1.60. Processor's gross margin, at 64 cents is 4 cents higher than their prior margin. Farmers receive

60 cents per gallon more for their milk. The $1.60 per gallon price is $18.59 per hundred pounds of milk.

Table 2: Pre-Regulation Prices and Simulated Post-Regulation Retail, Wholesale, and Raw Milk Prices in the Retailer Leadership Model (Given k = 1.32, c = 0.45)

Own Price Demand Elasticity	Post-Regulation Retail Price	Post-Regulation Wholesale Price	Post-Regulation Raw Price
4.30	2.42	1.86	1.33
4.10	2.46	1.89	1.35
3.90	2.50	1.92	1.37
3.70	2.54	1.96	1.40
3.50	2.60	2.00	1.43
3.30	2.66	2.05	1.46
3.10	2.74	2.11	1.51
3.04*	2.77	2.13	1.52
3.00	2.78	2.14	1.53
2.80	2.89	2.22	1.59
2.60	3.02	2.32	1.66
Pre-Regulation Prices	3.10	1.60	1.00

* Implied demand elasticity at retailing marginal cost of 45 cents.

This equilibrium result will change if one changes the price collar values. Table 2 elevates the retail price collar to 1.32. Note that equilibrium prices decline for each own price elasticity value. Now when own price elasticity is 3.04, retail price is $2.77 and wholesale price is $2.13 so retailer's margin is 65 cents. Since raw price is $1.52 processor's margin is 61 cents.

Table 3 gives results for k = 1.34. Again at the same elasticity level, 3.04, all prices are even lower. Retail margin is now 61 cents and processor margin is now 58 cents. Note that processors would most likely resist this outcome because it lowers their margin compared to pre-regulation.

Table 3: Pre-Regulation Prices and Simulated Post-Regulation Retail, Wholesale, and Raw Milk Prices in the Retailer Leadership Model (Given k = 1.34, c = 0.45)

Own Price Demand Elasticity	Post-Regulation Retail Price	Post-Regulation Wholesale Price	Post-Regulation Raw Price
4.30	2.31	1.78	1.27
4.10	2.35	1.80	1.29
3.90	2.39	1.83	1.31
3.70	2.43	1.87	1.34
3.50	2.48	1.91	1.36
3.30	2.54	1.96	1.40
3.10	2.62	2.01	1.44
3.04*	2.64	2.03	1.45
3.00	2.66	2.05	1.46
2.80	2.76	2.12	1.52
2.60	2.88	2.22	1.58
Pre-Regulation Prices	3.10	1.60	1.00

* Implied demand elasticity at retailing marginal cost of 45 cents.

Turning now to the processor leadership simulation model wholesale equilibrium prices are obtained from equation (16):

$$w_i = \frac{m}{m-1}\frac{\varepsilon_i}{1+\varepsilon_i}mc_i$$

Applying the price collars to this wholesale price gives the corresponding retail and raw prices. Table 4 gives the equilibrium prices for different wholesale own price demand elasticities, ε_i. As in the retail case we compute a calibrated demand elasticity at wholesale for the observed marginal processing cost and average wholesale price the pre-regulation period. It is 9.06. At elasticity 9.06 under regulation the processor maximizes profit by setting wholesale price at \$1.77, retail price then is \$2.30 and raw price is \$1.26. The retailer's margin is 53 cents, and the processor's earns only 51 cents.

Table 4: Pre-Regulation Prices and Simulated Post-Regulation Retail, Wholesale, and Raw Milk Prices in the Processor Leadership Model (Given k = 1.3, m = 1.4, mc = 0.45)

Own Price Demand Elasticity at Wholesale	Post-Regulation Retail Price	Post-Regulation Wholesale Price	Post-Regulation Raw Price
11.56	2.24	1.72	1.23
11.06	2.25	1.73	1.24
10.56	2.26	1.74	1.24
10.06	2.27	1.75	1.25
9.56	2.29	1.76	1.26
9.06*	2.30	1.77	1.26
8.56	2.32	1.78	1.27
8.06	2.34	1.80	1.28
7.56	2.36	1.82	1.30
7.06	2.39	1.83	1.31
Pre-Regulation Prices	3.10	1.60	1.00

* Implied demand elasticity at processing marginal cost of 45 cents.

One could explore the sensitivity of this result to changes in the wholesale price collar, but the more important insight is that the processor clearly will not prefer this outcome to his pre-regulation margin of 60 cents. Moreover in the bargaining game with retailers assuming k = 1.3 and retail own price elasticity = 3.04 the processor will readily acquiesce to the retailer's desired price vector. In equilibrium retail price will be \$2.91. Wholesale price will be \$2.24 and raw price will be 1.60. The processor prefers the retailer's preferred solution because it gives a 64-cent processing margin.

This result is concrete proof that retailers dominate the market channel. The source of this power relative to processors is the much less elastic pricing conditions that retailers enjoy compared to processors. If a processor raises price of its milk the next best alternative is sitting on the shelf next to its milk. If a retailer raises the price of all milk in its store the next best alternative is at some other retail outlet. Consumers are less likely to switch.

VI. Summary and Conclusion

When a commodity marketing channel becomes severely impacted by non-competitive pricing at one or more stages one might consider regulation to promote economic efficiency and redistribute revenue among claimants in the channel including consumers via lower prices. The theory of price collars developed in this paper links raw product, wholesale and retail prices in a three-stage channel. Analysis of retail and processor conduct before and after price collar regulation allows us to determine the conditions that must be met if a particular regulatory regime is to change retail, wholesale, and raw product prices in particular direction. We analyze the vertical pricing problem as either retailer or processor leadership and derive the equilibrium price vectors for both. They are a function of the price collars, marginal costs, and demand elasticities. Given each firm's best response in a vertical Nash game we show that the final equilibrium vector depends on bargaining between the firms.

When we simulate the theory for the fluid milk market in Southern New England we discover a result that clearly demonstrates retailer dominance. For the price collar parameters currently being contemplated in the policy debate and for known estimates of retailing supermarket own price and processor own price elasticities as well as known retail and processor marginal costs the retail solution dominates the processor solution. Processors have higher profits if they consent to the retailer's price offers in the bargaining game. Finally we demonstrate that the regulation agency can attain different price targets by changing the price collar value.

This analysis of price collars can be extended in several ways. The theory encompasses several brands; however the simulation only for an "all milk" aggregate. One could simulate the theory for multiple brands and assess implications for brand competition. One also needs to evaluate how the regulation would work if processors' and retailers' costs are heterogeneous. Elsewhere we have begun to address this issue through a "meeting the competition" clause that offers higher cost processors a higher price collar. We also address the cost of serving smaller accounts (Cotterill, 2003). The theory needs to be expanded to consider the impact of marginal costs that are functions of output. One could also to evaluate the institutional and legal structure of price collar regulation. Finally one might evaluate what "effective" is, i.e. what targets "should" a regulatory agency adopt?

REFERENCES

Blumenthal, Richard, Connecticut Attorney General. 2004. "Letter to Representative George Wilber with Attached Proposed Price Collar Law." January 26. Available at http://www.fmpc.uconn.edu. Click on Milk Price Gouging.

Choi, S. C. (1991). "Price Competition in a Channel Structure with a Common Retailer. *Marketing Science,* 10(4), Fall: 271-296.

Cotterill, Ronald W. 2003. "Drafting a Connecticut Fair Milk Pricing Law: A Meeting the Competition Clause that Enhances the Competitive Position of Connecticut Processors and a Small Account Rule that Recognizes the Higher Cost of Supplying Such Accounts." Food Marketing Policy Center Issue Paper No. 38, May. Available at http://www.fmpc.uconn.edu.

Cotterill, Ronald W. and Tirtha Dhar. 2003. "Oligopoly Pricing with Differentiated Products: The Boston Fluid Milk Market Channel." Food Marketing Policy Center, University of Connecticut, Storrs, CT. February 21. Available at http://www.fmpc.uconn.edu. Click on Milk Price Gouging.

Huff, Charles. 2003. "In-Store Milk Handling Costs." New York State Department of Agriculture & Markets, Division of Milk Control and Dairy Services, Albany, New York. April 17.

Maine Milk Commission. 2002. "Retail Margins." Maine State Department of Agriculture, Food and Rural Resources, Augusta, Maine. September 29.

Mohl, Bruce. 2003. "Dairy to Raise Milk Price." *Boston Globe*, Section E, January 9.

Pennsylvania Milk Marketing Board. 2000. "Findings of Fact and Conclusions of Law General Price Hearing for Milk Marketing Area No.2" Harrisburg, Pennsylvania. August 2.

Slade, M. 1995. "Product Rivalry with Multiple Strategic Weapons: An Analysis of Price and Advertising Competition." *Journal of Economics and Management Strategy*, 1995, 4(3), pp. 445 - 76.