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**Supermarket Chain Buyer Power in Action**

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## Private Labels: Supermarket Chain Buyer Power in Action

### I. Introduction

The issue of supermarket chain power in wholesale markets has been around at least since the 1930's when A&P surfaced as a nationwide chain with centralized buying (Adelman, 1959). Curiously those that complained the loudest were not firms that sold to supermarkets. Small retailers, who were unable to wrest concessions from brand manufacturers or wholesalers of fresh fruits and vegetables, alleged that large chain buyer power was driving them out of business. Consequently the Robinson Patman Act (1936) was passed to monitor the exercise of buyer power and its impact on smaller retailers as well as sellers. Enforcement has always been a thorny exercise because cost justified large buyer discounts are not illegal.

The very same issue of large chain buyer power is with us today in, if anything, a more robust context. Wal-Mart is the top supermarket chain with a 33% market share; and, the top 5 supermarket chains account for 68% of total U.S. supermarket sales (Market Scope, Marketing Guidebook). A food supplier who seeks national distribution must sell to these chains.

In Great Britain the issue of buyer power has also recently resurfaced in its classic form. The United Kingdom Competition Commission inquiry into the market power of the three leading supermarket chains, Tesco, Sainsbury, and Asda (Wal-Mart) has a buyer power thurst. A large vegetable farmer submitted the following statement to the Commission:

> "The fact that we no longer have a true market is illustrated by an example this week when cauliflowers are in short supply, the last week in May 2006. Tesco are paying £1 per cauliflower for imports from Germany but are offering no more than 50p for UK produced cauliflowers. Their argument will be that averaging the two cost prices allows them to maintain a middle range price for their customers. This is not new; I remember Sainsbury doing this in similar vein seven years ago when buying in expensive French cauliflowers and holding back the price of Kent cauliflowers. The retailers are such an important outlet year round that no packer or processor dare risk not supplying at times of shortage. Their fear of upsetting their retailer customers is far greater than their fear of

> upsetting their growers. Three years ago there was a shortage of potatoes. Potato packers, in some cases, lost a lot of money because the retailers would not reflect the shortage in their price at retail. The packers have reacted to this by offering programmes to suppliers at prices which barely cover the cost of production. There is an implied threat that if these "contracts" are not taken, they will not buy residual "free market" potatoes from the relevant supplier. This is an example of retailer pressure being transmitted down the chain. Again it has been effective because the retailers have rationalized their packer supply base which has reduced the opportunity for potato producers to find alternative outlets. (Tinsley 5/31/2006).

This brief introduction to buyer power indicates that a critical component is the rise of large chains that account for a large share of the purchases in a particular wholesale food market. Consequently one may have monopsony or oligopsony in that market; and, as a result wholesale prices are lower (at least for the large buyers) than they would otherwise be.

Yet this is not the full story. The central thesis of their paper is that buyer power can exist without a concentrated buying structure. Relatively small supermarket chains, for example those with sales above $500 million, can exercise buyer power through the provision of private label products.[1] Even smaller independent supermarkets that are affiliated with a cooperative wholesaler such as the Shop Rite/Wakefern Cooperative or with a voluntary wholesaler such as Super Valu can exercise buyer power. Private label products provide the retailer with leverage in the market place. When a retailer prices its private label and branded products the resulting impact on branded suppliers is that it is in their own best interest to lower wholesale prices. This buyer power does not depend on monopsonistic or oligopsonistic exploitation of an input supplier's positively sloped supply curve. It arises from the substitutability in final use of alternative differentiated products, for example, Skippy and Jiff brand peanut butter and the retailer's private label offer.

[1] A chain is defined as a firm with 11 or more supermarkets. Independents operate fewer stores.

No consensus on how to measure power in a vertical marketing channel currently exists. Stern and El Ansary (1982) maintain that a firm has power over others when it has control over the others' decision variables. A monopsonist has such power. It offers a price, take it or leave it. In a more competitive vertical channel retailer provision of private label may not dictate wholesale prices to branded manufacturers; however retailers may be able to influence wholesale prices. Messinger and Narasimhan (1995) and Kadiyali, Chintagunta, and Viccassim (2000) measure the relative power of manufacturers and retailers by their relative shares of total channel projects. This measure captures perhaps too much. It includes retailer selling power in consumer markets, as well retailer buying power in wholesale markets, and possibly manufacturer buying power in raw food input markets.

In this paper we adopt a simpler measure of buyer power than either of these. Retailers wield buyer power when they have the ability to depress wholesale prices. This is consistent with the standard definition of market power in the output market: the ability of a seller to raise price.

Several marketing economists have explored the pure theory of vertical market channel relations where retailers sell both branded products and private label. Four papers that illustrate the theory are Choi (1991), Lee and Staelin (1997), Raju, Sethmuraman, and Dhar (1995), and Mills (1995). Cotterill and Putsis (2001) test the Choi and Raju et al models for six products including fluid milk. The Choi model is not derived from an underlying utility model and Raju et al model is based only on a vertical form of the Shubik model which is derived from an underlying model of utility. Here we will test the Mills model and measure the impact of private label on the wholesale prices of branded products. Of the three models it is theoretically the most rigorous model. Mills starts with an indirect utility model and derives the demand equations in a fashion that identifies the underlying utility functions parameters. The model predicts that private label provision will lower wholesale prices. To our knowledge but for some preliminary work by Tian and Cotterill (2005) this is the first empirical test of the Mills model.

We analyze the market for fluid milk in Boston. Hood is the leading brand in terms of quality. Garelick is a secondary brand. During the period we study on average private label milk has by far the largest market share: 58% versus 24% for Garelick and 12% for Hood (See Table 1). After specifying and estimating the model we will analyze how changes in the provision of private label affect not only retail but wholesale branded milk prices. Specifically we wish to quantify the impact of private label pricing on wholesale prices. This serves as a direct measure of retailer buyer power in the wholesale milk market.

In the next section we generalize the Mills model and derive our supply side specification. Section 3 estimates it and analyzes results. Section 4 critiques the model and results. This leads to suggestions for further research.

## II. Model Specification

Mills (1995) developed an address model for a 2-good case to explain why retailers sell private label products. In this paper we generalize the model on the supply as well as the demand side. Following the Mills utility structure and generalizing to three brands: Hood, Garelick, and private label, one has:

$$u_h = \theta - p_h$$
$$u_g = \alpha\theta - p_g$$
$$u_l = \beta\theta - p_l \quad \text{for } 0 < \beta < \alpha \leq 1$$

Where $u_h$, $u_g$, and $u_l$ are utilities of consuming the 3 milk brands, $\theta$ is the gross utility from consumption, and $\alpha$ and $\beta$ are the substitution parameters that differentiate the 3 brands. If they equal unity then all brands are perfect substitutes. If a consumer consumes nothing, his or her utility is set to be zero, the lower bound for utilities. The upper bound is the reservation price minus the price of a brand.

Assuming $\theta$ has uniform distribution over the range (0, a)[2] and probability density function, $\frac{1}{b}$, one can derive the following demand functions:

1) $$q_h = \frac{a}{b} - \frac{p_h - p_g}{b(1-\alpha)}$$

2) $$q_G = \frac{p_H - p_G}{b(1-\alpha)} - \frac{p_G - p_L}{b(\alpha - \beta)}$$

3) $$q_l = \frac{p_g - p_l}{b(\alpha - \beta)} - \frac{p_l}{b\beta}$$

Note that the Mills demand system is linear in variables but nonlinear in parameters. It has a very constrained substitution pattern that generates a hierarchical demand system. Those who consume Hood milk only trade down to Garelick milk when Hood milk price rises. Those who consume Garelick milk can trade up to Hood milk or trade down to Private Label milk if Garelick milk price rises. Finally, those who consume Private Label milk trade up to Garelick milk or switch to an outside alternative.

For empirical work one can add fixed effect intercepts to position the address model within the broader context of factors that influence milk demand.[3] Restating the demand system in linear form and adding income and intercepts to the original demand equations to capture unobserved fixed effects gives the demand system that we estimate:

4) $$q_h = h_0 - h_1 p_h + h_1 p_g + h_2 Inc + v_g$$

5) $$q_g = g_0 + h_1 p_h - (h_1 + g_1) p_g + g_1 p_l + g_2 Inc + v_g$$

6) $$q_l = l_0 + g_1 p_g - (g_1 + l_1) p_l + l_2 Inc + v_l$$

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[2] a is the reservation price a consumer is willing to pay.

[3] For a rigorous proof see the data appendix to Tian and Cotterill (2005) as provided at www.fmpc.uconn.edu. Click on "journal reprints."

where $h_1 = \frac{1}{b(1-\alpha)}$, $g_1 = \frac{1}{b(\alpha-\beta)}$, $l_1 = \frac{1}{b\beta}$[4]. The underlying parameters α, β, and b can be recovered once all coefficients in the demand system are estimated. The value of the parameter a, the Mills reservation price, cannot be recovered since it is imbedded with-in the intercept and thus cannot be separated from the added constants that capture fixed effects. In effect one has a new more general reservation price for each of the brands.

Given this demand model Mills specifies the following market channel structure and vertical conduct. One retailer sells the three products and three manufacturers provide the product. The retailer maximizes category profits by setting the retail prices of the three products. The wholesale price of private label milk is assumed to be equal to the processor's marginal costs, i.e. either the retailer has integrated back into processing or it procures the product from a perfectly competitive private label milk processing industry. The two branded processors behave as Stakkelberg leaders and the retailer is a follower in this vertical pricing game. In other words the Hood and Garelick processors know the retailers reaction functions and use them to set wholesale prices.

We will generalize the supply side specification to include other pricing games. Vertical pricing of milk may be vertical Nash with or without a competitive private label pricing in the wholesale market. Alternatively, it may be manufacturer Stakkelberg with or without competitive private label pricing in the wholesale market. Furthermore, one may find a mixed strategy game. One possibility is that the brands play Stakkelberg and the private label channel may be vertical Nash. Thus we have five different supply side games, one of which is the Mills

[4] Greene (2003) proposes linear transformation or linear approximation to linearize nonlinear regression equations. In this model a linear transformation is able to linearize the demand functions. This simplifies estimation.

specification. Here we will derive the manufacturer Stakkelberg game without and with a competitive private label processor. The other models are presented in final form.[5]

We begin by stating the retailer's decision problem. The retailer maximizes category profits, $\pi_R$ by choosing values of $P_h$, $P_g$, and $P_l$ for the given demand specification and wholesale prices for the products: $W_h, W_g, W_l$:

$$\text{7)} \quad \underset{P_h, P_g, P_l}{\text{MAX}} \quad \pi_R = (P_h - W_h)Q_h(P_h, P_g, inc) + (P_g - W_g)Q_g(P_h, P_g, P_l, inc) + (P_l - W_l)Q(P_g, P_l, inc)$$

The retailers first order conditions are:

$$\text{8)} \quad h_0 - 2h_1P_h + 2h_1P_g + h_2\ inc + h_1W_h - h_1W_g = 0$$

$$\text{9)} \quad g_0 + 2h_1P_h - h_1W_h - 2(h_1 + g_1)p_g + 2g_1P_l + (h_1 + g_1)W_g + g_2\,inc - g_1W_l = 0$$

$$\text{10)} \quad l_0 + 2g_1P_g - g_1W_g - 2(g_1 + l_1)P_l + l_2\ inc + (g_1 + l_1)W_l = 0$$

Solving these first order conditions for the retailer's vertical reaction functions one obtains:

$$\text{11)} \quad P_h = \frac{1}{2}[G + H\,inc + W_h]$$

$$\text{12)} \quad P_g = \frac{1}{2}[D + F\ inc + W_g]$$

$$\text{13)} \quad P_l = \frac{1}{2}[A + B\,inc + W_l]$$

Where:

$$A = \frac{l_0 + g_0 + h_0}{l_1} \qquad\qquad B = \frac{g_2 + l_2 + h_2}{l_1}$$

[5] Derivations are available from the authors.

$$D = A + \frac{g_0 l_0 + h_0 l_1}{l_1 g_1} \qquad F = B + \frac{g_2}{g_1} + \frac{h_2 l_2}{g_1 l_1}$$

$$G = A + \frac{h_0}{h_1} + \frac{g_0 + h_0}{g_1} \qquad H = B + \frac{h_2}{h_1} + \frac{g_2 + h_2}{g_1}$$

Note that each product's profit maximizing retail price is a function of only its own wholesale price. This results from the restriction in the Mills demand specification that the cross price coefficients across demand equations be the same. More generally for any utility based demand system this result is due to Slutsky symmetry. What we then have are the retailer reaction functions that each manufacturer uses in the vertical Stakkelberg game to set its own wholesale price when maximizing profits.

Each of the three manufacturers maximizes their profits as follows ($c_i$ denotes the respective manufacturer's marginal cost):

14) $\underset{W_i}{\text{MAX}} \quad \pi_i = (W_i - c_i)Q_i$ where $i = h, g, l$

and $Q_h(P_h, P_g, inc)$
$Q_g(P_h, P_g, P_l, inc)$
$Q_l(P_g, P_l, inc)$

Since the processors know the retailer's reaction functions, in effect they set the products retail price when they set the wholesale price. We can use this fact to restate each manufacturers profit maximization problem with retail price rather than wholesale price as the choice variable. This eliminates wholesale prices from the model which is beneficial since we have only observations on retail price in our data. To eliminate wholesale prices we start by solving 11, 12, and 13 for $W_h, W_g, W_l$ respectively, and get:

15) $W_h = 2P_h - G - H\,inc$

16) $W_g = 2P_g - D - F\,inc$

17) $W_l = 2P_l - A - B\,inc$

We then substitute (15), (16) and (17) into the manufacturer profit maximization problems (14). Each manufacturer now maximizes profits by choice of their retail price. As an example, for Hood, one has:

$$\underset{P_h}{\text{MAX}} \qquad \pi_h = (2P_h - G - H\,inc - c_h)Q_h(P_h, P_g, inc)$$

The manufacturer's first order condition is:

$$2h_0 - 4h_1P_h + 2h_1P_g + 2h_2\,inc + Gh_1 + Hh_1\,inc + h_1C_h = 0$$

Solving for the Hood manufacturer's price reaction function from the first order condition one obtains:

$$(18) \qquad P_h = \frac{1}{2}\left(\frac{h_0}{h_1} + \frac{G}{2} + \left(\frac{h_2}{h_1} + \frac{H}{2}\right)inc + P_g + \frac{1}{2}c_h\right)$$

Similarly for Garelick one has:

$$(19) \qquad P_g = \frac{1}{2}\left(\frac{g_0}{h_1 + g_1} + \frac{D}{2} + \frac{h_1}{h_1 + g_1}P_h + \frac{g_2}{h_1 + g_1}P_l + \left(\frac{g_2}{h_1 + g_1} + \frac{F}{2}\right)inc + \frac{c_g}{2}\right)$$

Finally, if we allow the private label manufacturer to price according to vertical Stakkelberg conduct, substituting 17 into 14 one has:

20) $\pi_l = (2P_l - A - B\,inc - c_l)Q_l(P_g, P_l, inc)$

It then follows that the private label price reaction function is:

$$21) \qquad P_l = \frac{1}{2}\left(\frac{l_0}{g_1 + l_1} + \frac{A}{2} + \left(\frac{l_2}{g_1 + l_1} + \frac{B}{2}\right)inc + \frac{g_1}{g_1 + l_1}P_g + \frac{c_l}{2}\right)$$

To summarize, our address demand model with manufacturer Stakkelberg conduct has six equations: 4-6, 18, 19, and 21.

Assuming vertical Nash behavior we derive reaction functions in a similar manner and obtain:

22) $$P_h = \frac{1}{3}\left[G + \frac{h_0}{h_1} + \left(H + \frac{h_2}{h_1}\right)inc + P_g + c_h\right]$$

23) $$P_g = \frac{1}{3}\left[D + \frac{g_0}{h_1 + g_l} + \left(F + \frac{g_2}{h_1 + g_1}\right)inc + \frac{h_1}{h_1 + g_1}P_h + \frac{g_1}{h_1 + g_1}P_l + c_g\right]$$

24) $$P_l = \frac{1}{3}\left[A + \frac{l_0}{g_1 + l_1} + \left(B + \frac{l_2}{g_1 + l_1}\right)inc + \frac{g_1}{g_1 + l_1}P_g + c_l\right]$$

In the event the private label manufacturer has no market power it sells at a wholesale price that equals its marginal processing cost. Then $W_l = c_l$ and the private label manufacturer's profit maximization problem vanishes.

For the manufacturer Stakkelberg model with competitive private label processing we replace equation (21) with equation (13) with $W_l = c_l$. This gives:

25) $$P_l = \frac{1}{2}[A + B\ inc + c_l]$$

For vertical Nash pricing of the two brands and competitive private label pricing one replaces equation (24) with equation (25). The two new models are nested in the prior models so a nested test can easily be conducted to determine whether private label milk pricing is indeed effectively competitive. The last mixed strategy game has brands playing Stakkelberg and private label playing vertical Nash (equations 4-6, 18, 19, and 24). This allows for a less powerful private label processor, but a private label processor who still prices above marginal cost.

Thus we have five alternative models. Each has 3 demand equations and 3 price reaction equations. The endogenous variables are $Q_h, Q_g, Q_l$, and $P_h, P_g, P_l$. Note that we can use equations 15, 16, and 17 to recover estimates of the wholesale prices.

To identify each of the foregoing models one needs to specify brand level marginal cost functions. An additional requisite for identification, is to have brand specific cost shift variables. We will assume that the marginal costs of the three brands are derived from a Leontief production process:

26) $$mc_H = \lambda_{H0} + \sum_{i}^{k} \lambda_{Hi} w_{Hi}$$

27) $$mc_G = \lambda_{G0} + \sum_{i}^{k} \lambda_{Gi} w_{Gi}$$

28) $$mc_L = \lambda_{L0} + \sum_{i}^{k} \lambda_{Li} w_{Li}$$

Where w is a vector of input prices and cost shift variables, and $\lambda_{H0}, \lambda_{G0}$, and $\lambda_{L0}$ are the constant terms that help capture the unobserved effects in the marginal cost functions.

We use two variables to measure the raw milk price. The 3.5% butterfat milk price established by the Federal Milk Market Order or the Northeast Dairy Compact Commission is the price that processors pay in the Boston market. However the milk that they sell has less butterfat, a valuable byproduct. Therefore, we include the share of a brand's milk that is skim milk to measure the butterfat-adjusted cost of raw milk for each brand. We expect that variation in raw milk price explains variation in marginal cost and brand prices. Also a higher share of skim milk means lower raw milk marginal costs and lower brand prices.

A third variable is included to measure a brand's packaging costs. Units per gallon measures package size, for example, two units per gallon means that on average milk was sold in half-gallon containers. Brands with higher units per gallon are hypothesized to have higher packaging cost per gallon.

These cost variables might be endogenous. Raw milk price, however, is exogenous because it is set by the federal government and is not based upon Boston market conditions. A Durbin-Wu-Hausman test of the skim milk and packaging size variables indicates that they are not endogenous.

Labor and energy cost are two other major input factors for milk processing and retailing. However, specification tests using Amemiya's Prediction Criterion and the Schwartz Criterion show the inclusion of two publicly available cost variables, hourly wage rate and cents per kilowatt hour, generate poor performance. Therefore we do not use them.

## III. Data and Estimation Results

The retail level data are from Information Resources Inc (IRI) spanning 58 quad week periods commencing March 1996 through July 2000. The Boston IRI market includes the eastern half of Massachusetts. The raw milk price data is from the USDA. Table 1 gives descriptive statistics. The two columns identify the names of the variables used in the models. Hood is the highest priced brand, averaging $2.79 per gallon. Garelick, as specified in the address model, is a secondary brand positioned between Hood and private label. Average price is $2.78 per gallon which is less than Hoods price but well above the private label price, $2.49 per gallon. Market shares have an inverse relation to prices with private label having the largest share, 58%, Garelick having 28%, and Hood 12%. Note that units per gallon also has an inverse relation with price. This suggests that higher prices may be due to smaller package sizes. Share of skim milk may also explain higher prices as well.

Generalized Method of Moments (GMM) is used to estimate the simultaneous system of 6 equations in all models. Note that a nonlinear estimation routine is necessary because of cross equation restrictions in each of the models. GMM estimation brings efficiency gains in the presence of heteroscedasticity. If the disturbances are homoscedastic, then it is asymptotically the same as nonlinear 3-stage least square estimation (Greene, 2002).

Table 3 reports estimation results for the original Mills Address model specification. Here, the brands play Stakkelberg and private label is procured at a competitive wholesale price. First, note that the intercepts in the Garelick and private label demand equations are positive and extremely significant with *t* ratios of 5.53 and 25.24, respectively. Fixed effects exist and must be considered when estimating the Mills model. In Table 2, all of the reported demand price coefficients have the correct signs and are significant at the 1% level with *t* ratios at 12 or higher. The model constrains the negative of the Hood own price coefficient to be equal to the coefficient on Garelick in the Hood demand equation and the coefficient on Hood in the Garelick demand equation. This common absolute value is 1.7918 with a *t* ratio of 15. Similarly the cross price coefficients for Private Label and Garelick in this demand equation are constrained to be equal. The estimate is 3.1769 with a *t* ratio of 12, which is highly significant.

The estimated own price coefficient for Garelick is -4.9678 with a *t* ratio of -21.55 and for Private Label is -8.856 with a *t* ratio of -18.975. Both are highly significant. Our estimates of the address model's underlying $\alpha$ and $\beta$, substitution parameters, and b, the density parameter, are 0.4679, 0.1678, and 1.0489, respectively. These parameter estimates are plausible and within the specification bounds of the theory. The first two document that significant substitutability exists within the hierarchical brand structure. Per capita income has a positive significant effect on Hood and Garelick indicating that they are normal goods. Changes in income have no impact on private label consumption.

When examining estimation results for the brand price reactions in Table 2 one finds that the price reaction coefficients are very robust. Estimated coefficients for Hood and private label price in the Garelick price reaction equations are positive, as hypothesized, and significant at the 1% level. Garelick price reacts more to changes in private label than Hood price (.319 versus .18). The supply side in the original Mills model does not perform as well as the demand side. Raw milk price is not significantly different from zero for private label and Garelick. For Hood it has the wrong sign (negative) and is significant at the 1% level. As raw milk price increases, *ceteris paribus*, Hood retail milk prices go down. Possibly some of this implausible move is captured be collinear counter movements in the Hood share of skim milk and units per volume variables. Both have the hypothesized signs and are significant at the 1% level. These two variables also have the correct signs and are significant at the 1% level for Garelick and private label equations.

Table 3 gives estimation results when all the manufacturers play Stakkelberg. They are nearly identical to those of table 2, the original Mills model, with one exception. Here we estimate a first order condition (price reaction equation) for private label. Note that the Garelick price is specified in the last column of Table 3. It is positive .18 and significant at the 1% level with a *t* ratio of 11.95. Since this coefficient is significant the original Mills model with competitive private label pricing in the wholesale market does not hold. To confirm this a nested test was performed and the null hypothesis of competitive wholesale pricing for private label is rejected in favor the alternative full manufacturer Stakkelberg specification. It appears that private label milk processors conduct in the Boston market is best captured by manufacturer Stakkelberg, not competitive pricing.

Table 4 presents estimates of the model with vertical Nash conduct by the three processors and retailer. In Table 5 the results for brand vertical Nash conduct with competitive pricing for just private label are presented. The estimation results vary little from what we observed in Table 2 and 3. Again a nested test rejected competitive wholesale pricing for private label milk in favor of the alternative all vertical Nash specification.

The last variation of the model is another mixed game specification. In Table 6 Hood and Garelick play Stakkelberg and private label plays vertical Nash. These results are essentially the same as those in Table 3 where all processors play Stakkelberg and Table 5 where all processors play vertical Nash.

Distinguishing between the models in Tables 3, 5, and 6 becomes a question of which non-nested test can be applied to non-linear instrumental variable GMM. Since there is no distributional assumption on the error structure for GMM, testing methods for fully parametric models cannot be considered, more on this shortly. As a consequence we attempted to implement Davidson and MacKinnon's (1981) *P* test by generalizing it to the non-nested systems we estimate.[6] This attempt proved to be unsuccessful in that the artifical estimation required to compute the test statistic could not converge to GMM estimates of the parameters. Since the purpose of non-nested tests such as the *P* are not to choose out of a fixed set of models a best one we would like to pursue methods that deal with criteria for model selecting.

Specifically, selecting a model that would be considered best out of a fixed set could be done by implementing a test from the likelihood ratio paradigm. As we highlighted above GMM does not employ a distributitonal assumption on the error structure. Therefore, computation of the likelihood ratio statistic depends critically on the supposition that the weighting matrix used in the criterion function satisfies certain efficiency conditions.[7] These conditions are only satisfied when a model is just identified (Davidson and MacKinnon 1993). Therefore,

[6] We also attempted a *J* test but because the system is highly non-linear, as one might expect, computation of a test statistic by using the artifical regression method was not feasible.
[7] When these efficiency conditions are met the likelihood ratio statistic can be computed by taking the difference between the criterion functions for the restricted and unrestricted models respectively.

computing a likelihood ratio statistic is not plausible for the over identified systems we estimate. That being said, in future extensions of this research, a Full Information Maximum Likelihood (FIML) estimation routine could be used. Davidson and MacKinnon (1993) suggest for estimating non-linear systems, like ours, FIML is more efficient than the alternative non-linear three stage least squares (NL3SLS) and asymptotically equivalent to the chosen GMM. FIML will allow one to compute a likelihood ratio statistic for over identified systems. Hence a test from the likelihood ratio family could be performed. Vuong (1989) suggests a test from the likelihood ratio family specifically designed for non-nested models. In the future if FIML estimation is feasible, this would be our test of choice. However, given that the statistical results for the three alternative games are so similar we are doubtful that one game dominates the other in a statistically significant way.

## IV. Measuring the Impact of Private Label on Retail and Wholesale Prices of brand Products

Mills theory predicts that the introduction of private label will lower both the retail and the wholesale prices of branded products (See Mills 1995, Figure 2 and related explanation). In other words retailers have buyer power without necessarily dominating the milk processing industry. We measure private label power over brand pricing in the following fashion. Using the original Mills model results (Table 2) first we compute the equilibrium prices with all the exogenous variables held constant at the mean values. Next we set the private label quantity at zero and use the resulting private label demand equation with the price reaction equations of Hood and Garelick to simultaneously compute the private label reservation price and brand prices when no private label is purchased. Results are provided in Table 7. The first now gives model equilibrium retail prices for the products and the wholesale prices for the two brands. The

Garelick wholesale price is, \$1.65 and the Hood wholesale price is, \$1.80, which are estimates recovered from the model.

Row two of Table 7 gives the retail and wholesale prices when private label price is at or above the reservation price (price at which consumers buy no private label). As expected elevating the private label price to the level \$3.26 causes and elevation in the retail and wholesale market prices for Hood and Garelick. Subtracting row 1 from row 2 in Table 7 gives the impact of private label provision on branded retail and wholesale prices. Branded prices at retail drop 14 and 7 cents for Garelick and Hood Respectively. Brand Prices at wholesale drop even more, 27 cents for Garelick and 14 cents for Hood. Thus introduction of private label increases the retailer's unit profit margin on both brands. Total profits will depend on the volume impact on brand sales.

## V. Summary and Suggestions for Further Research

In this paper we demonstrate that the Mills address model, even with its very restrictive demand side specification, explains the fluid milk market extremely well. We generalize the two good demand model to three goods with fixed effects. On the supply side we generalized the original Mills specifications to include several other possible vertical games. Models that assume competitive private label processing do not perform as well as the other models. This suggests that private label processors in the Boston market have some market power. Statistically there is no difference between the more general models.

Private label provision, as illustrated with results from the original Mills specification does depress wholesale prices as well as retail brand prices. Retailers do have buyer power when they sell private labels.

Future research would attempt to improve the cost specification in these models, possibly using a flexible Leontief rather than linear functional form. Also, as suggested earlier a different estimation routine will allow provides us with a more powerful test for choosing among non-nested models. Finally, one could estimate these models with more disaggregate chain as opposed to market level data.

Table 1: Descriptive Statistics of Variables

| Variable | Description of Variable | Mean | St. Dev | Minimu | Maximu |
|---|---|---|---|---|---|
| $p_H$ | Price of Hood | 2.97 | 0.19 | 2.69 | 3.36 |
| $p_G$ | Price of Garelick | 2.78 | 0.25 | 2.46 | 3.29 |
| $p_L$ | Price of Private Label | 2.49 | 0.20 | 2.21 | 2.85 |
| $q_H$ | Sales Volume of Hood | 0.84 | 0.21 | 0.52 | 1.18 |
| $q_G$ | Sales Volume of Garelick | 1.78 | 0.31 | 1.20 | 2.41 |
| $q_L$ | Sales Volume of Private Label | 4.26 | 0.36 | 3.45 | 4.90 |
| $p_{RAW}$ | Price of Raw Milk | 1.48 | 0.11 | 1.27 | 1.77 |
| $s_H$ | Market Share of Hood | 0.12 | 0.03 | 0.17 | 0.06 |
| $s_G$ | Market Share of Garelick | 0.24 | 0.03 | 0.30 | 0.20 |
| $s_L$ | Market Share of Private Label | 0.58 | 0.02 | 0.62 | 0.52 |
| Inc | Per Capita Income | 19022 | 2086 | 16509 | 22219 |
| $ug_H$ | Units per Gallon for Hood | 1.67 | 0.15 | 1.50 | 1.97 |
| $ug_G$ | Units per Gallon for Garelick | 1.52 | 0.09 | 1.22 | 1.66 |
| $ug_L$ | Units per Gallon for Private Label | 1.29 | 0.02 | 1.24 | 1.33 |
| $ss_H$ | Share of Skim Milk Sales for Hood | 8.66 | 2.61 | 4.63 | 12.78 |
| $ss_G$ | Share of Skim Milk Sales for Garelick | 18.43 | 1.95 | 14.42 | 22.15 |
| $ss_L$ | Share of Skim Milk Sales for Private Label | 39.09 | 1.53 | 34.89 | 42.43 |

Prices and income are deflated by Consumer Price Index.

TABLE 2. Empirical Results for Mills Original Model: Manufacturer Stakkelberg Brand Conduct and Competitive Wholesale Prices for Private Label

| variable | qh | qg | ql | ph | pg | pl |
|---|---|---|---|---|---|---|
| constant | 0.25785 | 1.7318 | 16.16 | 1.0634677 | 1.3813183 | 1.5979 |
| | 1.147 | ***5.5392 | ***25.428 | ***14.025 | ***17.1635 | ***19.304 |
| ph | -1.7918 | 1.7918 | | | 0.1803087 | |
| | ***-15.091 | ***15.091 | | | ***12.662 | |
| pg | 1.7918 | -4.9687 | 3.1769 | a 0.5 | | |
| | ***15.091 | ***-21.555 | ***12.508 | | | |
| pl | | 3.1769 | -8.856 | | 0.3196913 | |
| | | ***12.508 | ***-18.975 | | ***22.449 | |
| inc | .00005 | .00003 | 3.927E-05 | 3.292E-05 | 1.875E-05 | 1.066E-05 |
| | ***7.8565 | *1.8554 | 0.96602 | ***7.18 | ***5.063 | ***4.742 |
| praw | | | | -0.70152 | -0.037651 | 0.10843 |
| | | | | ***-5.6103 | -0.36865 | 1.1046 |
| ss_h | | | | -0.054472 | | |
| | | | | ***-4.859 | | |
| ss_g | | | | | -0.14337 | |
| | | | | | ***-23.737 | |
| ss_pl | | | | | | -0.028842 |
| | | | | | | ***-9.5964 |
| ug_h | | | | 0.86367 | | |
| | | | | ***5.8247 | | |
| ug_g | | | | | -0.60289 | |
| | | | | | ***-7.9051 | |
| ug_l | | | | | | -3.9475 |
| | | | | | | ***-8.7341 |

note: t ratios appear below coefficient estimates
*** significant at 1% level
** significant at 5% level
* significant at 10% level
a This value is determined in the model and is not estimated

TABLE 3. Empirical Results: Manufacturer Stakkelberg Vertical Conduct for all Products

| Variable | qh | qg | ql | ph | pg | pl |
|---|---|---|---|---|---|---|
| Constant | 0.16159 | 1.8461 | 16.37 | 1.0020078 | 1.3594834 | 1.666617 |
| | 1.147 | ***5.7832 | ***25.695 | ***13.533 | ***17.813 | ***27.502 |
| Ph | -1.688 | 1.688 | | | 0.1678133 | |
| | ***-14.853 | ***14.853 | | | ***13.097 | |
| Pg | 1.688 | -5.0294 | 3.3414 | a 0.5 | | 0.1809743 |
| | ***14.853 | ***-21.604 | ***12.3272 | | | ***11.959 |
| pl | | 3.3414 | -9.2317 | | 0.3321867 | |
| | | ***12.372 | ***-21.589 | | ***25.926 | |
| inc | 0.00005479 | 0.0000285 | .00005 | .000036 | .0000187 | .0000115 |
| | ***7.8565 | *1.6412 | 1.2812 | ***7.698 | ***5.067 | ***5.4898 |
| praw | | | | -0.72215 | -0.041553 | 0.12119 |
| | | | | ***-5.7034 | -0.41234 | 0.90858 |
| ss_h | | | | -0.058187 | | |
| | | | | ***-5.0527 | | |
| ss_g | | | | | -0.14473 | |
| | | | | | ***-23.524 | |
| ss_pl | | | | | | -0.046461 |
| | | | | | | ***-13.637 |
| ug_h | | | | 0.89959 | | |
| | | | | ***5.8166 | | |
| ug_g | | | | | -0.59496 | |
| | | | | | ***-7.6631 | |
| ug_l | | | | | | -5.0753 |
| | | | | | | ***-8.1071 |

note: t ratios appear below coefficient estimates
*** significant at 1% level
** significant at 5% level
* significant at 10% level
a This value is determined in the model and is not estimated

TABLE 4. Empirical Results for Vertical Nash Brand Conduct and Competitive Wholesale Price for Private Label

| Variable | qh | qg | ql | ph | pg | pl |
|---|---|---|---|---|---|---|
| Constant | -0.059154 | 2.2756 | 15.071 | 1.5831862 | 2.121203 | 1.758 |
| | -0.40368 | ***7.3841 | ***25.671 | ***23.313 | ***17.532 | ***17.814 |
| Ph | -1.5803 | 1.5803 | | | 0.1174848 | |
| | ***-13.897 | ***13.897 | | | ***12.34 | |
| Pg | 1.5803 | -4.4837 | 2.9034 | a 0.3333 | | |
| | ***13.897 | ***-18.778 | ***11.884 | | | |
| Pl | | 2.9034 | -7.8201 | | 0.2158485 | |
| | | ***11.884 | ***-18.109 | | ***22.672 | |
| Inc | .0000659 | -.00000067 | .0000029 | .0000045 | .0000399 | .00000693 |
| | ***9.1128 | -0.04 | 0.082 | 1.511 | ***7.638 | ***6.99 |
| Praw | | | | -0.62578 | 0.018668 | 0.1419 |
| | | | | ***-5.6441 | 0.17227 | 1.2933 |
| ss_h | | | | -0.019677 | | |
| | | | | **-1.9229 | | |
| ss_g | | | | | -0.14675 | |
| | | | | | ***-29.674 | |
| ss_pl | | | | | | -0.026577 |
| | | | | | | ***-9.7366 |
| ug_h | | | | 0.88922 | | |
| | | | | ***6.4937 | | |
| ug_g | | | | | -0.68859 | |
| | | | | | ***-9.8255 | |
| ug_l | | | | | | -4.3426 |
| | | | | | | ***-7.869 |

note: t ratios appear below coefficient estimates
*** significant at 1% level
** significant at 5% level
* significant at 10% level
a This value is determined in the model and is not estimated

TABLE 5. Empirical Results for Vertical Nash Conduct for all Products

| variable | qh | qg | ql | ph | pg | pl |
|---|---|---|---|---|---|---|
| constant | -0.1202 | 2.3423 | 14.381 | 1.6739136 | 2.2833967 | 1.9301974 |
| | -0.841 | ***7.6859 | ***25.994 | ***20.732 | ***16.373 | ***20.073 |
| ph | -1.5199 | 1.5199 | | | 0.113927 | |
| | ***-13.38 | ***13.38 | | | ***12.552 | |
| pg | 1.5199 | -4.447 | 2.9271 | a 0.3333 | | 0.1340395 |
| | ***13.38 | ***-20.197 | ***13.096 | | | ***12.792 |
| pl | | 2.9271 | -7.2792 | | 0.2194063 | |
| | | ***13.096 | ***17.72 | | ***24.174 | |
| inc | .000069 | -.0000034 | -.0000332 | .000018 | .0000399 | .0000009 |
| | ***9.7921 | -0.2135 | -0.99824 | 0.566 | ***7.155 | 0.262 |
| praw | | | | -0.62492 | 0.057678 | 0.23024 |
| | | | | ***-5.5196 | 0.50595 | *1.5996 |
| ss_h | | | | -0.015695 | | |
| | | | | -1.4714 | | |
| ss_g | | | | | -0.15246 | |
| | | | | | ***-29.076 | |
| ss_pl | | | | | | -0.040537 |
| | | | | | | ***-12.349 |
| ug_h | | | | 0.97354 | | |
| | | | | ***6.7056 | | |
| ug_g | | | | | -0.76504 | |
| | | | | | ***-10.585 | |
| ug_l | | | | | | -6.2658 |
| | | | | | | ***-9.769 |

note: t ratios appear below coefficient estimates
*** significant at 1% level
** significant at 5% level
* significant at 10% level
a This value is determined in the model and is not estimated

TABLE 6. Empirical Results for Hood and Private Label Stakkelberg, and Private Label Vertical Nash Conduct

| variable | qh | qg | ql | ph | pg | pl |
|---|---|---|---|---|---|---|
| constant | 0.16329 | 1.8207 | 15.529 | 1.0737 | 1.4615 | 1.7488 |
| | 1.1279 | *** 5.8212 | ***25.843 | ***13.0509 | ***17.1894 | ***22.4663 |
| ph | -1.7068 | 1.7068 | | | 0.1701 | |
| | ***-14.721 | ***14.721 | | | ***12.7676 | |
| pg | 1.7068 | -5.0162 | 3.3093 | a 0.5 | | 0.1306 |
| | ***14.721 | ***22.6889 | ***13.659 | | | ***13.0954 |
| pl | | 3.3093 | -8.448 | | 0.3299 | |
| | | ***13.659 | ***-18.9908 | | ***24.7551 | |
| inc | 0.000055 | 0.00003 | 0.000001 | 0.000035 | 0.000014 | 0.0000056 |
| | ***7.6508 | *1.7529 | 0.0331 | ***7.0619 | ***4.1263 | *1.8266 |
| praw | | | | -0.72344 | -0.0034 | 0.15484 |
| | | | | ***-5.6504 | -0.0319 | 1.1876 |
| ss_h | | | | -0.0529 | | |
| | | | | ***-4.5046 | | |
| ss_g | | | | | -0.1514 | |
| | | | | | ***-22.836 | |
| ss_pl | | | | | | -0.0433 |
| | | | | | | ***-11.856 |
| ug_h | | | | 0.97206 | | |
| | | | | ***6.16 | | |
| ug_g | | | | | -0.69015 | |
| | | | | | ***-8.8062 | |
| ug_l | | | | | | -5.7178 |
| | | | | | | *** -10.936 |

note: t ratios appear below coefficient estimates
*** significant at 1% level
** significant at 5% level
* significant at 10% level
a This value is determined in the model and is not estimated

TABLE 7. The Impact of Private Label Provision on the Pricing of Branded Products: Boston Fluid Milk Market

| | P_pl | P_g | P_h | W_g | W_h |
|---|---|---|---|---|---|
| Equilibrium Prices with Private Label in the Market | $2.85 | $3.61 | $3.60 | $1.65 | $1.80 |
| Equilibrium Prices with Private Label at the Reservation Price (i.e. no Private Label Supplied) | $3.26 | $3.75 | $3.67 | $1.92 | $1.94 |
| The Impact of Private Label on Brands (row 1-2) | | -$0.14 | -$0.07 | -$0.27 | -$0.14 |

**References**

Adelman, M. A. 1959. *A&P: A Study in Price-Cost Behavior and Public Policy.* Cambridge: Harvard University Press. pp. 237 and 242.

Choi, S. 1991. Price competition in a channel structure with a common retailer. *Marketing Sci.* 10(4) 271-296.

Cotterill, R.W., W. Putsis, Jr. 2001. Do models of vertical strategic interaction for national and store brands meet the market test? *J. Retailing.* 77 83-109.

Davidson, R., J. G. MacKinnon. 1981. Several test for model specification in the presence of alternative hypothesis. *Econometrica*. 49(3) 781-793.

Davidson, R., J. G. MacKinnon. 1993. *Estimation and Inference in Econometrics*. Oxford University Press, New York, NY.

Green, W.H. 2003. *Econometric Analysis*, *fourth edition*. Prentice Hall, Upper Saddle River, NJ.

Kadiyali,V., P. Chintagunta, N. Vilcassim. 2000. Manufacturer-retailer channel interactions and implications for channel power: An empirical investigation of pricing in a local market. *Marketing Sci.* 19(2) 127-148.

Lee, E., R. Staelin. 1997. Vertical strategic interaction: Implications for channel pricing strategy. *Marketing Sci.* 16(3) 185-207.

Messinger, P., C. Narasimhan. 1995. Has power shifted in the grocery channel? *Marketing Sci.* 14(2) 189-223.

Mills, D.E. 1995. Why retailers sell private labels. *J. Econom. Management Strategy* 4(3) 509-528.

Raju, J., S. Dhar, R. Sethuraman. 1995. The introduction and performance of store brands. *Management Sci.* 41(6) 957-978.

Stern L., A. El-Ansary. 1982. *Marketing Channels, Second Edition.* Prentice-Hall, Inc., Englewood Cliffs, NJ.

Tian, L., R.W. Cotterill. 2005. Constrained price, address, or logit brand demand models: An econometric comparison in the Boston fluid milk market. *Agribusiness: An International J.* 21(2) 149-166.

Tinsley, M. 2006. Groceries Market – Third party submissions from suppliers. Submission from farmer No. 1. Competition Commission. Available at http://www.competition-commission.org.uk/inquiries/ref2006/grocery/

Vuong, Q. H. 1989. Likelihood ratio test for model selection and non-nested hypotheses. *Econometrica*. 57(2) 307-333.

*2006 Market Scope Mid-Year Update*. 2006. Trade Dimensions International, Wilton, CT.

*2007 Marketing Guidebook*. 2006. Trade Dimensions International, Wilton, CT.

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