"VERTICAL CONTRACTS BETWEEN MANUFACTURERS AND RETAILERS: INERENCE WITH LIMITED DATA"

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MOTIVATION

• Why do we care?

  Efficiency
  
  Double Marginalization or more efficient contracting?

  Competition

  Balance of power

  Beyond IO,
  
  Modeling retailer behavior, e.g. Price dynamics
  
  (Chevalier, Kashyap, Rossi, AER, 2003)
  
  International Economics (cost pass-through)

• Why is it difficult to analyze?

  Limited data observability (wholesale prices, costs)

  Non-marginal components
• Present method to analyze degree of competitive interactions between manufacturers and retailers (vertical contracts) even when wholesale prices are unobserved

• Apply methodology to a certain market (yogurt)
GENERAL STRATEGY

- Estimate brand-store level demand (using flexible functional form)

- Given demand estimates, compute price-cost margins (PCM) for retailers and manufacturers implied by different supply models (without observing wholesale prices)
  
  Each model implies different PCM for retailers and manufacturers

- Test between different supply models by asking which set of implied PCM is more compatible with "observed" PCM (using non-nested tests)
CONCLUSIONS

• Model that best fits the data:

  Marginal wholesale price close to marginal cost and retail price is the unconstrained profit-maximizing price

• Able to rule out Double Marginalization model

• Consistent with several scenarios, for example:

  1. Retailers have large bargaining power
  2. Non-linear pricing by manufacturers
     Two-part tariffs
     Quantity discounts
  3. Others…
     unobservable contracts (of rivals)
OUTLINE

• Related literature
• Illustrative example
• The models (demand and supply)
• Estimation method
• Testing between supply models
• The data
• The yogurt market
• Results
• Conclusions and Extensions
RELATED LITERATURE

• Extensive theoretical work on vertical contracts

For a survey see Katz (1989).

• Empirical work:
  Bresnahan and Reiss (1985)
  Corts (2000)
  Mortimer (2002)

  Closer to this paper:
  Messinger and Narasimhan (95)
  Chintagunta, Bonfer and Song (2000)
  Kadiyali, Chintagunta and Vilcassim (2000)
  Main differences: use data on wholesale prices, just one retailer.

• Tests of vertical pricing models (very few):

  Sudhir (2001), Villas-Boas and Zhao (2001)

  Main difference: just one retailer.
ILLUSTRATIVE EXAMPLE

Manufacturer A

Retailer X

P_1

P_2

Retailer Y

P_3

Consumers

Manufacturer B
SUPPLY MODELS CONSIDERED

- Simple Linear Pricing ⇒ Double Marginalization
- Vertically Integrated
- Alternative (Strategic) models:
  - Non-linear pricing (2 "special/extreme" cases)
    - Wholesale pricing at marginal cost
    - Retail margin close to zero
  - Retailers vertically integrated in private labels
  - Manufacturer level collusion
  - Retail level collusion
# THE SUPPLY MODELS

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Manufacturers: m</th>
<th>Retailers: r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Linear Pricing</td>
<td>( \max \pi_{mj} \text{ given } p(p^w) )</td>
<td>( \max \pi_{rj} )</td>
</tr>
<tr>
<td>Zero wholesale margin</td>
<td>( p^w = c^w )</td>
<td>( \max \pi_{rj} )</td>
</tr>
<tr>
<td>Zero retail margin</td>
<td>( \max \pi_{mj} )</td>
<td>( p = p^w + c^r )</td>
</tr>
<tr>
<td>Private Label</td>
<td>( p^w = c^w ), for ( j = \text{private label} ) and otherwise ( \max \sum_j \pi_{mj} \text{ given } p(p^w) )</td>
<td>( \max \pi_{rj} )</td>
</tr>
<tr>
<td>Manufacturer collusion</td>
<td>( \max \sum_j \pi_{mj} \text{ given } p(p^w) )</td>
<td>( \max \pi_{rj} )</td>
</tr>
<tr>
<td>Retail collusion</td>
<td>( \max \pi_{mj} \text{ given } p(p^w) )</td>
<td>( \max \sum_j \pi_{rj} )</td>
</tr>
<tr>
<td>Joint profit maximizing</td>
<td>( \max \sum_j \pi_j )</td>
<td>( \max \sum_j \pi_j )</td>
</tr>
</tbody>
</table>
SIMPLE LINEAR PRICING MODEL

- Manufacturers set wholesale prices and then given the wholesale prices retailers set retail prices

- Max $\pi_{rt} = \sum_{j \in S_{rt}} [p_{jt} - p_{jt}^{w} - c_{jt}^{r}] s_{jt}(p) - FC$

\[ s_{jt} + \sum_{k \in S_{rt}} [p_{kt} - p_{kt}^{w} - c_{kt}^{r}] \frac{\partial s_{kt}(p)}{\partial p_{jt}} = 0, \quad j = 1, \ldots, N. \]

Define

$T_r : T_r(i,j) = 1$ when $i,j \in S_{rt}$ and 0 otherwise

$\Delta_r$ is a matrix of cross-price elasticities of demand

Solving for the PCM of the retailers

$\mathbf{p} - \mathbf{p}^{w} - \mathbf{c}^{r} = - (T_r \cdot \Delta_r)^{-1} s(p)$ \quad (1)
Manufacturers

$$\pi_{wt} = \sum_{j \in S_{wt}} \left[ p_{jt}^w - c_{jt}^w \right] s_{jt}(p) - FC_{wt}^w$$

given that retailers price according to

$$p - p_w^c = - \left( T_r \cdot \Delta_r \right)^{-1} s(p) \tag{1}$$

Rearranging the first order conditions, to solve for the PCM of the manufacturers (in matrix notation)

$$p_w^c - c = - \left( T_w \cdot \Delta_w \right)^{-1} s(p) \tag{2}$$

where

$$T_w(i,j) = 1 \text{ when } i,j \in S_{wt} \text{ and } 0 \text{ otherwise and}$$

$$\Delta_w$$ has the cross-price elasticities of derived demand (has also effect of cost pass-through).

**Note:** $S_{wt} \neq S_{rt}$.  

- The PCM for the other models are obtained from (1) and (2).
DEMAND MODEL

• Discrete choice model for differentiated products

• Indirect latent utility from consumer \( i \) choosing product \( j \) (brand-store) at time \( t \)

\[
U_{ijt} = D_t + d_j + x_{jt} \beta_i - \alpha_i p_{jt} + \xi_{jt} + \epsilon_{ijt}
\]

- \( d_j \) product dummy variables, \( D_t \) seasonal dummies
- \( x_{jt} \) observed product characteristics
- \( \epsilon_{ijt} \) distribution of consumer preferences about unobserved product characteristics (will be integrated out)

• What is in \( \xi_{jt} \)? Changes in
  - unobserved consumer preferences
  - other unobserved market specific conditions
    (e.g. unobserved promotions, previous sales, changes in shelf display)
• Specifying consumer heterogeneity

\[
\begin{align*}
\alpha_i &= \alpha + \phi_D D_i + \phi_v \nu_i \\
\beta_i &= \beta
\end{align*}
\]

$D_i$ observed and $\nu_i$ unobserved consumer characteristics

Note: if $\alpha = \alpha_i$ and $\beta = \beta_i$ (and $\epsilon$ extreme value) ⇒ Logit.

• Consumer purchases one unit of the good that gives the highest utility conditional on characteristics, prices and outside good.

• Aggregate market share of product $j$

\[
s_{jt} = \int \{ (D_i, \nu_i, \epsilon_i) \mid U_{ijt} \geq U_{ihjt}, h = 0, \ldots, N \} \ dF(\epsilon) \ dF(\nu) \ dF(D)
\]
DEMAND ESTIMATION

• Estimate demand parameters that produce predicted aggregate market shares close to observed ones

• Data requirements:
  
  Prices in different markets (weeks)
  Aggregate market shares
  Product characteristics
  Consumer characteristics

• Problem of estimation - prices are correlated with $\zeta_{ijt}$

• Solution: Use instruments for prices

• Need instruments with product level variation

• I use two instrumental variable (IV) specifications:

  1. Manufacturer level input prices interacted with brand-store dummy variables & Retail level input prices

  2. Manufacturer-level input prices interacted with brand dummy variables & Retail level input prices
**TESTING THE SUPPLY MODELS**

1. **Test of each supply model:**

   - Starting with the accounting identity obtained by adding up the implied PCM

     \[ p - c^w - c^r = PCM_r + PCM_w \]

   - Having information on costs \((c^r + c^w)\) I can compare the implied PCM with PCM obtained from estimates of cost.

     This reduces to estimating the supply pricing equation

     \[ p = c \gamma + PCM_r \lambda_r + PCM_w \lambda_w + \varepsilon \]

     and to test if the \(\lambda\) are jointly significantly different from 1

2. **Comparing different supply models:**

   - Models are not particular cases of other models

   - Non-nested testing procedures

     **Intuition:** Given a null model how “likely” is the alternative model?
THE DATA

- Scanner data collected at several retail stores in two markets over two years - Source: IRI

  Weekly UPC-store level data on prices and quantities for 24 product categories (used yogurt category)

- Demographics at Zip Code level - Source: Census 1990

- Product characteristics - Source: Label reads
THE INPUT DATA

- **Manufacturer level input prices**
  
  **Input Prices** | **Sources**
  ----------------|-----------------|
  - Citric acid   | Chemical Week   |
  - Plastic       | Chemical Marketing Reporter |
  - Sugar         | Coffee,Sugar & Cocoa Exchange |
  - Non-fat Grade A milk | Cheese Market News, USDA |
  - Whey Protein  | Cheese Market News, USDA |
  - Strawberry    | Nat. Agric. Stats, USDA |
  - Interest rate | Federal Reserve  |
  - Wages         | CPS Annual Earning File-NBER 50 |
  - Ohio (plant Dannon) |
  - Illinois (plant Kraft, Private Label store 3, retailers) |
  - Michigan (plant Yoplait) |
  - Oregon (plant Private Label store 2) |

  - Gasoline prices | Petroleum Marketing Monthly |
  - Industrial energy prices | EIA – 826, Table 53 |
  - for states OH,IL,MI, OR |

- **Retail level input prices**
  
  **Input Prices** | **Sources**
  ----------------|-----------------|
  - Real Estate Indices | CB Richard Ellis |
  - Commercial energy prices | EIA – 826, Table 53 |
  - Chain size
    - Number employees | Human Resources Chains |
    - Number stores | Human Resources Chains |
  - Gasoline prices | Petroleum Markt. Monthly |
YOGURT MARKET

• Why yogurt?
  
  Short time storable good (ignore dynamic aspects)
  Not heavily promoted by retailers (implications for IV)
  Small number of key industry players
  Reasonably established private labels

• Why should we care about yogurt?
  
  Application of the general method to a local market

• Manufacturers
  
  Dannon and General Mills (Yoplait) 62% yogurt sales
  Private labels 15%
  Kraft 5%
  All others have individual shares less than 2%

• Retailers in local market
  
  Three retail chains have jointly 75% sales

• Local market
  
  Mid-west metropolitan area between 1991-93
  2 Zip Code areas
DATA

• Definition of variables

**Price**: in cents per serving, 1 serving = 6 ounce cup

<table>
<thead>
<tr>
<th>Mean</th>
<th>Median</th>
<th>Std</th>
<th>Min</th>
<th>Max</th>
<th>Brand Variation</th>
<th>Week Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>49</td>
<td>48</td>
<td>9.2</td>
<td>24</td>
<td>72</td>
<td>68.3%</td>
<td>2.4%</td>
</tr>
</tbody>
</table>

**Potential market**: half a serving per capita a week

⇒ half the population in two Zip Code areas

International patterns (per capita servings/week)

- Bulgaria: 3.4 (Lactobacillus bulgaricus)
- France: 1.9; Germany: 1.2; USA: 0.53; Canada: 0.3

**Market shares**: servings sold / total potential servings

<table>
<thead>
<tr>
<th>Combined Shares</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dannon</td>
<td>17%</td>
<td>5%</td>
<td>50%</td>
</tr>
<tr>
<td>General Mills</td>
<td>9%</td>
<td>4%</td>
<td>31%</td>
</tr>
<tr>
<td>Store 1</td>
<td>2%</td>
<td>1%</td>
<td>9%</td>
</tr>
<tr>
<td>Store 2</td>
<td>20%</td>
<td>58%</td>
<td>10%</td>
</tr>
<tr>
<td>Store 3</td>
<td>13%</td>
<td>7%</td>
<td>24%</td>
</tr>
</tbody>
</table>
DATA

**Outside good**: products sold at other retailers

- **Demographics**
  - Median household income: US$ 30,000/year
  - Median household size: 2.5 persons

- **Product Characteristics**
  - Store 2 dummy
  - Store 3 dummy
  - Total calories
  - Vitamin A and C content dummy
  - Calcium content
  - Aspartame content dummy
  - Available in different sizes dummy
RESULTS

- Demand

Results from Random Coefficients model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Interaction with Log(Income)</th>
<th>Interaction with Age</th>
<th>Interaction with Unobserv.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-7.91* (0.25)</td>
<td>0.07 (0.55)</td>
<td>5.55 (1.43)</td>
<td>0.35 (0.26)</td>
</tr>
<tr>
<td>Price</td>
<td>-5.69 (0.70)</td>
<td>1.25 (0.28)</td>
<td>-2.43 (2.14)</td>
<td>0.93 (0.48)</td>
</tr>
<tr>
<td>Store 2</td>
<td>3.03* (0.04)</td>
<td>1.56 (0.41)</td>
<td>-6.11 (0.55)</td>
<td>0.07 (0.13)</td>
</tr>
<tr>
<td>Store 3</td>
<td>1.21* (0.04)</td>
<td>1.43 (0.51)</td>
<td>-5.54 (0.59)</td>
<td>0.15 (0.15)</td>
</tr>
<tr>
<td>Calories</td>
<td>-0.25* (0.01)</td>
<td>0.002 (0.002)</td>
<td>-0.006 (0.007)</td>
<td>0.08 (0.05)</td>
</tr>
<tr>
<td>Calcium</td>
<td>5.81* (0.14)</td>
<td>0.44 (0.16)</td>
<td>0.25 (0.02)</td>
<td>0.28 (0.11)</td>
</tr>
<tr>
<td>Aspartame</td>
<td>-5.81* (0.21)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Different Sizes</td>
<td>4.65* (0.13)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Standard errors are in parenthesis. Regression included brand dummy variables, seasonal dummy variables and allows for a non-linear interaction of price with log income. * Estimates from minimum distance procedure.
RESULTS

• Demand - Are IV working?

First Stage
$R^2=0.82$
Wald test \{instruments' coefficients=0\}=1809 (421)

Sample coefficients (first stage)

<table>
<thead>
<tr>
<th>Product</th>
<th>Plastic</th>
<th>Milk</th>
<th>Wage IL</th>
<th>Wage MI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail Price of Yoplait</td>
<td>0.006</td>
<td>0.128</td>
<td>0.031</td>
<td>0.015</td>
</tr>
<tr>
<td>Custard Low-fat Fruit</td>
<td>(0.002)</td>
<td>(0.058)</td>
<td>(0.012)</td>
<td>(0.007)</td>
</tr>
<tr>
<td>Retail Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Alternative Specification

NNLS: not instrumenting for price
- coefficients change considerably
- PCM change also

• Demand - Additional Specification Tests

1. set $v_i = 0$ - estimates, PCM unchanged
2. robust to potential market definition

3. Demand specification with feature
   IV versus OLS
   PCM and ranking of models unchanged
   Cannot reject exogeneity test for feature
RESULTS

• Demand - Price Elasticities

Within store
Mean Cross Price Elasticity
  Product Average  0.035
  Store 1 Average  0.009
  Store 2 Average  0.055
  Store 3 Average  0.034

Example

<table>
<thead>
<tr>
<th></th>
<th>Changes in price of Dannon</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Classic Fruit</td>
<td>Lowfat Plain</td>
</tr>
<tr>
<td>Dannon Light Fruit</td>
<td>0.175</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Across stores
Mean Cross Price Elasticity
  Product Average 0.030
  Store 1 Average  0.025
  Store 2 Average  0.035
  Store 3 Average  0.032

Persistent substitution patterns

• Demand - flexible? Comparison to Logit

Overcome Logit restrictions in terms of cross-elasticities
(Variance of cross-price elasticities is not zero)
# RESULTS

- **Price Cost Margins**

<table>
<thead>
<tr>
<th>Model</th>
<th>Wholesale Margin Mean</th>
<th>Wholesale Margin Std</th>
<th>Retail Margin Mean</th>
<th>Retail Margin Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double Marginalization</td>
<td>38.3%</td>
<td>8.2</td>
<td>37.9%</td>
<td>8.7</td>
</tr>
<tr>
<td>Zero wholesale margin</td>
<td>0</td>
<td>0</td>
<td>37.9%</td>
<td>8.7</td>
</tr>
<tr>
<td>Zero retail margin</td>
<td>37.3%</td>
<td>8.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vertical Integration Private labels</td>
<td>30.8%</td>
<td>14.6</td>
<td>37.9%</td>
<td>8.7</td>
</tr>
<tr>
<td>Wholesale collusion</td>
<td>46.4%</td>
<td>11.3</td>
<td>37.9%</td>
<td>8.7</td>
</tr>
<tr>
<td>Retail collusion</td>
<td>39.8%</td>
<td>8.4</td>
<td>42.0%</td>
<td>9.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Efficient vertical pricing</th>
<th>Mean</th>
<th>Std</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>42.0%</td>
<td>9.6</td>
</tr>
</tbody>
</table>
### Recovered Costs

<table>
<thead>
<tr>
<th>Estimated Costs / Model</th>
<th>Percent Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Linear Pricing</td>
<td>8.4% 0.132</td>
<td>0.091</td>
<td>-0.164</td>
<td>0.377</td>
</tr>
<tr>
<td>Zero Wholesale Margin</td>
<td>0% 0.316</td>
<td>0.089</td>
<td>0.049</td>
<td>0.548</td>
</tr>
<tr>
<td>Zero Retail Margin</td>
<td>0% 0.314</td>
<td>0.091</td>
<td>0.043</td>
<td>0.550</td>
</tr>
<tr>
<td>Hybrid Model Wholesale Collusion</td>
<td>1.8% 0.161</td>
<td>0.089</td>
<td>-0.163</td>
<td>0.422</td>
</tr>
<tr>
<td>Retail collusion</td>
<td>14% 0.094</td>
<td>0.095</td>
<td>-0.233</td>
<td>0.354</td>
</tr>
<tr>
<td>Monopolist</td>
<td>13% 0.105</td>
<td>0.090</td>
<td>-0.195</td>
<td>0.351</td>
</tr>
<tr>
<td></td>
<td>0% 0.294</td>
<td>0.091</td>
<td>0.021</td>
<td>0.530</td>
</tr>
</tbody>
</table>

- **Hypothesis Testing**

  Comparisons between models
RESULTS

- Non-Nested Tests

**Intuition:** Given a null model how likely is the alternative?

<table>
<thead>
<tr>
<th>Models</th>
<th>1</th>
<th>2.1</th>
<th>2.2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Double Marginaliz.</td>
<td>-</td>
<td><strong>1.88</strong></td>
<td>1.26</td>
<td>1.75</td>
<td>2.55</td>
<td>1.58</td>
<td>2.11</td>
</tr>
<tr>
<td>2.1 PCM(_w)=0</td>
<td><strong>0.93</strong></td>
<td>-</td>
<td><strong>0.16</strong></td>
<td><strong>0.58</strong></td>
<td><strong>0.68</strong></td>
<td><strong>0.85</strong></td>
<td><strong>0.12</strong></td>
</tr>
<tr>
<td>2.2 PCM(_r)=0</td>
<td>1.09</td>
<td><strong>3.77</strong></td>
<td>-</td>
<td>0.56</td>
<td>0.76</td>
<td>1.19</td>
<td>2.15</td>
</tr>
<tr>
<td>3 Private label</td>
<td>0.40</td>
<td><strong>3.26</strong></td>
<td>0.16</td>
<td>-</td>
<td>0.39</td>
<td>0.28</td>
<td>2.08</td>
</tr>
<tr>
<td>4 Wholesale collusion</td>
<td>2.05</td>
<td><strong>1.88</strong></td>
<td>0.55</td>
<td>1.15</td>
<td>-</td>
<td>1.06</td>
<td>2.29</td>
</tr>
<tr>
<td>5 Retail collusion</td>
<td>0.99</td>
<td><strong>4.04</strong></td>
<td>2.43</td>
<td>0.58</td>
<td>0.82</td>
<td>-</td>
<td>2.13</td>
</tr>
<tr>
<td>6 Vertical efficient</td>
<td>0.13</td>
<td><strong>2.08</strong></td>
<td>0.02</td>
<td>0.22</td>
<td>0.19</td>
<td>0.09</td>
<td>-</td>
</tr>
</tbody>
</table>

One side tests, critical value of 1.65 at 5% significance.

**Conclusions:**

Model 2.1 provides the best fit

Results similar in alternative demand specifications
EXTENSIONS / APPLICATIONS

• Extensions

  1. Look at vertical contracts across different markets
  2. Look at more than one category (in progress)

• Applications

  1. Vertical merger analysis

     Does a potential merger affect horizontal competition?
     Future project (dairy industry)
     See also Manuszak (2001)

  2. Pass-through of trade policies (tariffs, depreciations)
     Who absorbs most of policy change - foreign or domestic margins? (See Hellerstein, N,Y. Fed working paper, 2004)

  3. Measure marginal cost advantages from exclusive dealing (see Asker, Harvard working paper, 2004)

  4. Price discrimination:
     Fair wholesale price legislation in Gasoline markets in California (as a motivation for future project)
     Test for wholesale price discrimination (in progress)
CONCLUSIONS

• Method to analyze vertical contracts without wholesale prices

• Empirical model of competing manufacturers' and retailers' decisions (related literature does not model retailers' decisions)

• Rule out Double Marginalization model

• Model that best fits the data:

  Marginal wholesale pricing close to marginal cost and retailers choose profit-maximizing prices

• Consistent with several scenarios, for example:

  1. Retailers having large bargaining power

  2. Non-linear pricing by manufacturers
     Two-part tariffs
     Quantity discounts

  3. Others...