Competitive Package Size Decisions

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Introduction

Background
- Why do manufacturers offer different package sizes?
- Why do manufacturers reduce the size of some products?
- Manufacturers are seeking ways to soften price competition. Does reducing package size fly in the face of those broader efforts?

Current Orthodoxy
- Consumers do not have precise information about package size (e.g. Binkley and Bejniorovicz 2003).
- Consumers are not responsive to unit price changes (e.g. Cakir and Balagats 2014).
- Package downsizing makes the comparison of unit price difficult (e.g. Ellison and Ellison 2009).
- Manufacturers reduce package size to pass along price increase.
- Manufacturers are able to extract surplus from package downsizing.

Real-World Observation
- Why do manufacturers change package sizes less frequently? Can the current orthodoxy explain it?

Research Objective
- Investigate how manufacturers choose package size and price in a competitive environment

Hypotheses
- Consumers base their purchase decisions on package size.
- Manufacturers incur the costs of making different packages.
- Manufacturers compete in price and package size.
- Consider role of package size as a competitive tool
- Show interdependence of price and package size
- Provide evidence of semi-collision in package size
- Explain package downsizing in terms of cost and competition
- Change in package size is costly.
- Raising unit prices by package downsizing is not easy due to competition

Model

Consumer
- Consumers are assumed to be heterogeneous, make a discrete and hierarchical choice among differentiated products.
- Utility within the random coefficient generalized extreme value (GEV) framework:
  \[ u_{it} = x_{it}'\alpha + \bar{p}_it\bar{p} + f(q_{it}) + \psi d_{it} + \omega(p_{it} \times d_{it}) + \xi_{it} + \tau_{it} (1-\sigma)\tau_{it} \]
- \( \bar{p}_it \): Retail price
- \( q_{it} \): Package size

\( f(\cdot) \): Contribution to utility by purchase quantity (Draganska and Jain 2005), \( f(q_{it}) = f(0) + f'(0) q_{it} + \frac{f''(0)}{2} q_{it}^2 = \gamma \tau_{it} q_{it} + \gamma_2 q_{it}^2 \)
- \( d_{it} \): Price discount (dummy variable)
- \( \xi_{it} \): Id term that reflects product attributes that are relevant, but unobserved to the econometrician
- \( \tau_{it} \): GEV extreme-value distributed term (Cardell 1997)
- \( \sigma = 0 \) indicates a competitive market

Retailer
- We assume the Stackelberg competition (e.g. Besanko, Dube and Gupta 2003; Villas-Boas and Zhao 2005; Villas-Boas 2007).
- Retailers are assumed to pass through manufacturers’ package size decisions, and set prices and act as local monopolist.
- Retailer’s profit maximization problem:
  \[ n_t^i = \max 0 \sum (n_t - c_t n_t) n_t - F_t \]
  \( I \): Index of product
  \( Q_t \): Market size
  \( P_t \): Retail price
  \( c_t \): Retailing cost
  \( s_t \): Market share
  \( F_t \): Fixed retailing cost

First order condition with conduct a parameter, \( \rho \) (in matrix notation):
- \( p - r = \left( \frac{\partial}{\partial q} \right) \Psi \)
- \( \Omega = 1 \times 1 \) matrix where the \((i,j)\) element is given by \( \frac{\partial^2 u_i}{\partial q_j} \)

Manufacturers
- Manufacturers are assumed to set package sizes and wholesale prices simultaneously and compete in both of them.
- Manufacturer’s profit maximization problem:
  \[ n_t^m = \max 0 \sum (w_t - c_t n_t) n_t - F_m - \sum h(q_{it}) l_{m_t} \]
  \( l_{m_t} \): Index of product that manufacturer \( m \) offers
  \( Q_t \): Market size
  \( w_t \): Wholesale price
  \( c_t \): Marginal cost
  \( s_t \): Market share
  \( F_m \): Fixed cost
- First order condition with respect to wholesale prices with a conduct parameter, \( \varphi \) (in matrix notation):
  \[ w - c = -\left( \frac{\partial^2 u_t}{\partial q_t} \right) \]
- First order condition with respect to package sizes with a conduct parameter, \( \eta \) (in matrix notation):
  \[ \eta = \eta_t + \eta_t (w - c) \]

Estimation
- Two-stage estimation method (Yang, Chen, and Allenby 2003)
- Demand-side model: Simulated maximum likelihood (SML) method with a control function (Perlin and Train 2010; Park and Gupta 2009)
- Supply-side model: Seemingly unrelated regressions (SUR) model with a control function

Data
- Store-level scanner data (IRI Infoscan) provided by 2 major retail chains in a US metropolitan market
- Ready-to-eat breakfast cereal category for 3 years (April 2007-March 2010)
- 35 major SKUs (15 out of 35 products changed package size.)
- Manufacturer pricing data by Promodata, Inc.

Results
- Consumers prefer smaller packages. Preference for package size is heterogeneous.

Table 1: Estimation Result of Demand-Side Model
<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient Estimate</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package size Mean coefficient</td>
<td>-0.157*</td>
<td>-2.746</td>
</tr>
<tr>
<td>Std. dev. of coefficient</td>
<td>0.019*</td>
<td>213.126</td>
</tr>
<tr>
<td>Log likelihood at convergence</td>
<td>4,258</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Conduct Parameters of Supply-Side Model
<table>
<thead>
<tr>
<th>Model</th>
<th>Retail price equation</th>
<th>Manufacturer price equation</th>
<th>Manufacturer package size equation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.00065*</td>
<td>4.93713</td>
<td>0.00003*</td>
</tr>
<tr>
<td></td>
<td>3.25769*</td>
<td>3.37530</td>
<td></td>
</tr>
</tbody>
</table>

The positive conduct parameter in the package-size equation means wholesale prices and package sizes are strategic complements.
- \( q_1 = q_0 + \eta_1 (w_1 - c_1) + \eta_2 (w_2 - c_2) \) (product 1)
- \( q_2 = q_0 + \eta_1 (w_1 - c_1) + \eta_2 (w_2 - c_2) \) (product 2)

- What happens if the size of Cheerios 15/14 oz. is reduced by 10%? Price competition is sharpened and manufacturers lose, but retailers gain.

Table 3: Response of manufacturers and retailers
<table>
<thead>
<tr>
<th>Product</th>
<th>Wholesale price (%)</th>
<th>Package size (%)</th>
<th>Manufacturer margin (%)</th>
<th>Retail price (%)</th>
<th>Retail margin (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheerios 15/14 oz.</td>
<td>-0.931</td>
<td>-1.815</td>
<td>-65222.099</td>
<td>0.084</td>
<td>0.263</td>
</tr>
<tr>
<td>Frosted Flakes 17 oz.</td>
<td>0.029</td>
<td>0.007</td>
<td>-9784</td>
<td>0.003</td>
<td>0.008</td>
</tr>
<tr>
<td>Rice Krispies 12 oz.</td>
<td>-0.078</td>
<td>0.018</td>
<td>-16212</td>
<td>0.002</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Conclusions and Implications
- Consumers prefer smaller packages. ⇒ Manufacturers should launch at least one small-pack product.
- Preference for package size is heterogeneous. ⇒ Manufacturers should offer multiple packages.
- Package-size decisions depend on demand, cost, and competition.
- Package downsizing mitigates the effects of price increase.
- Reason why manufacturers simultaneously lower the package and raise the unit price of a product
- Package size and price are strategic complements.
- Ability to raise unit prices through changes in package sizes is constrained by competition.
- Reason why manufacturers seldom lower package sizes
- Package upsizing softens price competition.
- Reason why manufacturers launch larger packages
- Retailers gain more from package downsizing than manufacturers.
- Package size and price are interdependent.
- Manufacturers cannot easily pass-through cost increases through package downsizing.
- Retail prices increase slower than once thought.