Competitive Package Size Decisions

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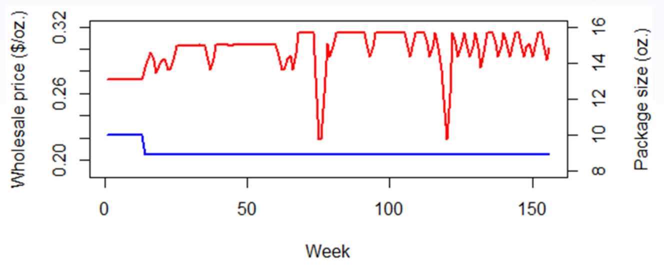
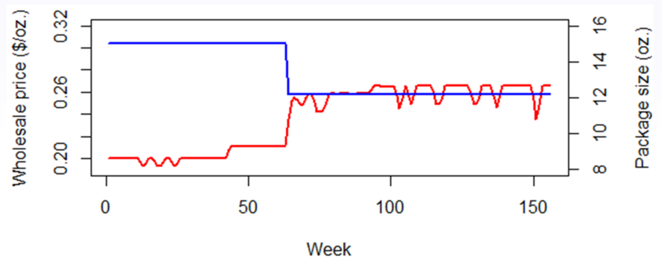
Introduction

Back Ground
- 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 Bejnarowicz 2003).
- Consumers are not responsive to unit price changes (e.g. Cakira and Balagtas 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.

Contributions

- Consider role of package size as a competitive tool
- Show interdependence of price and package size
- Provide evidence of semi-collusion 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:

$$U_{hijt} = \alpha_{hb} + \beta_{ht} p_{ijt} + f(q_{it}) + \psi d_{ijt} + \omega(p_{ijt} \times d_{ijt}) + \xi_{ijt} + \tau_{hijt} + (1-\sigma)\varepsilon_{hijt}$$

  p_{ijt}: Retail price
  q_{it}: Package size
  $f(\cdot)$: Contribution to utility by purchase quantity (Draganska and Jain 2005), $f(q_{it}) = f(0) + f'(0)q_{it} + \frac{f''(0)}{2}{q_{it}}^2 = \gamma_{1ht}q_{it} + \gamma_{2t}{q_{it}}^2$
  d_{ijt}: Price discount (dummy variable)
  ξ_{ijt}: iid error term that reflects product attributes that are relevant, but unobserved to the econometrician
  $\tau_{hijt} + (1-\sigma)\varepsilon_{hijt}$: GEV extreme-value distributed term (Cardell 1997)
- Market share

$$s_{ijt} = \iiint \frac{exp(\delta_{ijt}+\phi_{hijt})/(1-\sigma)}{D_J^{\sigma}\left(\sum_{j\in J} D_J^{1-\sigma}\right)} g_1(\iota) g_2(\kappa) g_3(\lambda) d\iota d\kappa d\lambda$$

Vertical Relationship
- We assume the Stackelberg competition (e.g. Besanko, Dubé and Gupta 2003; Villas-Boas and Zhao 2005; Villas-Boas 2007).

Retailers
- Retailers are assumed to pass through manufacturers' package size decisions, and set prices and act as local monopolist.
- Retailer j's profit maximization problem:

$$\pi_t^j = \max_{p_{it}} Q_t \sum_{i=1}^{I} (p_{it} - r_{it}) s_{it} - F_{jt}$$

  I: Index of product
  Q_t: Market size
  p_{it}: Retail price
  r_{it}: Retailing cost
  s_{it}: Market share
  F_{jt}: Fixed retailing cost
- First order condition with conduct a parameter, ρ (in matrix notation):
- $p - r = -\left(\left(\frac{1}{\rho}\right)\Omega\right)^{-1} s$
- Ω : $I \times I$ matrix where the (i,j) element is given by $\frac{\partial s_j}{\partial p_i}$

Manufacturers
- Manufacturers are assumed to set package sizes and wholesale prices simultaneously and compete in both of them.
- Manufacturer m's profit maximization problem:

$$\pi_t^m = \max_{w_{it}, q_{it}} Q_t \sum_{i=1}^{I_{mt}} (w_{it} - c_{it}) s_{it} - F_{mt} - \sum_{i=1}^{I_{mt}} h(q_{it})$$

  I_{mt}: Index of product that manufacturer m offers
  Q_t: Market size
  w_{it}: Wholesale price
  c_{it}: Marginal cost
  s_{it}: Market share
  F_{mt}: Fixed cost
  $h(q_{it})$: Package-size cost function e.g. set-up, inventory, and distribution costs, $h(q_{it}) = \theta_0 + \theta_1 q_{it} + \theta_2 q_{it}^2$
- First order condition with respect to wholesale prices with a conduct parameter, φ (in matrix notation):

$$w - c = -\varphi\left((G^{-1}\Omega)\Omega * I_N\right)^{-1} s$$

- First order condition with respect to package sizes with a conduct parameter, η_1 (in matrix notation):

$$q = \eta_0 + \eta_1 Q \Gamma (w - c)$$

Estimation
- Two-stage estimation method (Yang, Chen, and Allenby 2003)
- Demand-side model: Simulated maximum likelihood (SML) method with a control function (Pertin 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

Table 1: Estimation Result of Demand-Side Model

Variable	Parameter	Estimate	t-value
Package size	Mean coefficient	−0.157*	−2.746
	Std. dev. of coefficient	0.019*	213.126
Log likelihood at convergence		4,258	

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

Table 2: Conduct Parameters of Supply-Side Model

Model	Estimate	t-value
Retail price equation	0.00065*	4.93713
Manufacturer price equation	0.00003*	6.68000
Manufacturer package-size equation	3.25769*	3.37530

- Market is more competitive than the maintained assumptions.
- Prices are less responsive to changes in demand induced by competitors' price changes.

- The positive conduct parameter in the package-size equation means wholesale prices and package sizes are strategic complements.

$$q_1 = \eta_0 + \eta_1 \left[(w_1 - \underset{-}{c_1}) \frac{\partial s_1}{\partial q_1} + (w_2 - \underset{+}{c_2}) \frac{\partial s_2}{\partial q_1} \right] \quad \text{(product 1)}$$

$$q_2 = \eta_0 + \underset{+}{\eta_1} \left[(w_1 - \underset{+}{c_1}) \frac{\partial s_1}{\partial q_2} + (w_2 - \underset{-}{c_2}) \frac{\partial s_2}{\partial q_2} \right] \quad \text{(product 2)}$$

- $w_1 \uparrow \Rightarrow q_1 \downarrow$: Manufacturers use changes in package size to mitigate the effects of price increase.
- $q_1 \downarrow \Rightarrow w_1 \uparrow \Rightarrow q_2 \uparrow \Rightarrow w_2 \downarrow$: A package downsizing intensifies price competition.

- What happen 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

Product	Wholesale price (%)	Package size (%)	Manufacturer margin (%)	Retail price (%)	Retail margin (%)
Cheerios 15/14 oz.	−0.951	−1.015	−6522.209	0.084	0.263
Frosted Flakes 17 oz.	−0.029	0.007	−9.784	0.003	0.008
Rice Krispies 12 oz.	−0.078	0.018	−16.212	0.002	0.006

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.
- Package downsizing intensifies price competition.
  - 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.