A MULTIPLE DISCRETE CONTINUOUS MODEL OF RETAIL PRICE PROMOTION

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Objective

- To estimate the effectiveness of price promotions in a fresh fruit category
  - Develop a demand framework that is more consistent with shopping behavior and data collection in produce categories

Motivation

- Understanding the effectiveness of promotional pricing has always been important in food marketing
  - Effects decisions of whether, what, and how much to buy (Gupta, 1988; Chiang, 1991; Bell et al. 1999; Nijs et al., 2001; Van Heerde et al., 2003)
- Promotional activity is getting more complicated and retailers are paying more and more attention to analytics

Motivation

Title	Patent Number	Issue Date
Econometric Optimization Engine	U.S. Patent 7,672,866	3/2/2010
System for Creating an Optimized Promotion Event Calendar	U.S. Patent 7,660,734	2/9/2010
Financial Model Engine	U.S. Patent 7,657,470	2/2/2010
Price Optimization with Rule Relaxation	U.S. Patent 7,617,119	11/10/2009
Price Optimization System	U.S. Patent 7,523,047 B1	4/21/2009
Intelligent Clustering System	U.S. Patent 7,386,519	6/10/2008
Rule Relaxation and Subset Optimization System	New Zealand Patent 533065	3/13/2008
Econometric Optimization Engine	U.S. Patent 7,302,410 B1	11/27/2007
Interface for Selective Merchandise Price Optimization	U.S. Patent 7,249,031	7/24/2007
Apparatus and Method for Selective Merchandise Price Optimization	U.S. Patent 7,249,033	7/24/2007
Selective Merchandise Price Optimization Mechanism	U.S. Patent 7,249,032	7/24/2007
Interface for Merchandise Price Optimization	U.S. Patent 7,240,019	7/3/2007
Method and Apparatus for Providing Price Updates	Singapore Patent 117629	3/30/2007

Motivation

- Growing importance of fresh produce in retail competition
  - Supermarket produce offering in 90s: 173-335 (Berner, 1999)
  - Consumption expected to increase from 2000-2020 (Biing-Hwan, 2004)
    - Apples – 28%
    - Citrus – 28%
    - Grapes – 24%
    - Tomatoes – 19%
    - Lettuce – 22%

Motivation

- Fresh produce accounts for nearly 12% of all U.S. supermarket sales - $48 billion (Chanil, 2009)
- Consumers regularly compare retailers based on quality and price of fresh produce
  - (Dickson & Urbany, 1994)
- Quality of fresh fruits and vegetables often more important determinant of store patronage than convenience/location
  - (Turcsik & Heller, 2000)
- Growth of new retail formats built around high quality produce offerings

Motivation

fresh & easy™ Neighborhood Market

SUNFLOWER FARMERS MARKET

WHOLE FOODS MARKET

FROM FARM TO STORE IN TWENTY-FOUR 24 HOURS

"Our produce is a sight to behold. It's the first thing you see when you come into one of our stores: a visual feast of color, variety and sparkling freshness piled high for your pleasure and convenience" – Whole Foods Website

Motivation

- Temporary Price Reductions (TPR) are important in the fresh produce category

Temporary Price Reductions by Category

Category	$ (Billions)	% Sales TPR
All	367	16
Beverages	19	16
Packaged Meat	10	21
Dry Goods	142	16
Frozen Goods	30	20
Fresh Produce	14	29

Source: Nielsen Homescan, 2008

Motivation

- Growers increasingly support fresh produce TPR
  - Generic advertising challenged in Supreme Court
    - First Amendment Issue
      - Wileman Bros. case
      - United Foods case
      - LMA marketing case
  - Product differentiation and branding increasing in produce
    - Store image through produce quality
    - National brands for CPGs same across retailers

Motivation

- Little research on promotional effectiveness in the produce category
  - Some price promotion research that distinguishes between perishable and nonperishables
  - Finding that category incidence caused by discounts is higher for perishables (Ailawadi and Neslin 1998; Nijs et al. 2001; Pauwels et al. 2002)

Problem

- Modeling produce demand is non-standard
  - Consumers may buy several variants from category
  - Purchase continuous quantities of each variant (lbs.)
- Demand for variety for at least two reasons
  - Shoppers anticipate consumption (Dube, 2004)
  - Consumers face diminishing marginal utility (Wales & Woodland, 1983; Kim et al., 2002; Bhat, 2005)

Problem

- What demand framework should we use?
  - Discrete choice? (Chintagunta, 1993)
    - Hard to accommodate demand for variety
    - Can't handle continuously defined quantities
  - Representative consumer model? (Duffy, 1991)
    - Not appropriate for differentiated product demand (Nevo, 2001)
  - Discrete/Continuous model? (Dubin & McFadden, 1984; Hanneman, 1984)
    - Doesn't accommodate demand for variety

Problem

- Solution
  - Synthesis of two approaches
    - Hendel (1999) and Dube (2004) – Multiple Discreteness
    - Bhat (2005, 2008) – extends to continuous quantity
      - Multiple Discrete Continuous Extreme Value (MDCEV) model

Contribution

- Extend MDCEV to study TPR is produce category
- New method of measuring perceived quality
- Spatial model to account for:
  - Demographic segmentation
  - Quality/Variety differentiation
  - Temporal relationships in demand
  - Distance Metric (DM) framework
    - Pinkse & Slade (2004), Slade (2004), Pofahl & Richards (2009)

Empirical Model

$$u_j^h(q_{ij}^h, \mathbf{D}^h, \theta) = \frac{1}{\alpha_i}\exp(\varepsilon_{1j}^h)(q_{1j}^h)^{\alpha_i} + \sum_{i=2}^{I}\frac{\gamma_i}{\alpha_i}\left(\phi_{ij}^h\left(\frac{q_{ij}^h}{\gamma_i}+1\right)^{\alpha_i} - 1\right)$$

where

q_{ij}^h = quantity of variant i purchased by HH h on occasion j

$\mathbf{D}^h$ = vector of demographics describing each HH

ε_{1j}^h = a product- and HH-specific random term

ϕ_{ij}^h = the perceive quality, or baseline utility

α = a curvature parameter (between 0 and 1)

γ = the product-specific translation parameter

Empirical Model

$$\phi_{ij}^{h} = \exp\left(\tau_i + \beta_i d_{ij} + \pi_i \mathbf{D}^{h} + (\lambda_1 \mathbf{T} + \lambda_2 \mathbf{S} + \lambda_3 \mathbf{M})\mathbf{p} + \varepsilon_{ij}^{h}\right)$$

- Solving U-Max using Kuhn Tucker conditions

$$P(q_{1j}^{h}, q_{2j}^{h}, \ldots, q_{mj}^{h}, 0, 0 \ldots 0) = \frac{1}{\sigma^{M-1}} \left(\prod_{k=1}^{M} g_k\right) \left(\sum_{k=1}^{M} \frac{p_k}{g_k}\right) \left(\frac{\prod_{k=1}^{M} e^{V_{kj}^{h}/\sigma}}{\left(\sum_{i=1}^{I} e^{V_{ij}^{h}/\sigma}\right)^{M}}\right) (M-1)!$$

$$V_{ij}^{h} = \ln \phi_{ij}^{h} - \varepsilon_{ij}^{h} + (\alpha_i - 1)\ln(q_{1j}^{h} / \gamma_1 + 1) - \ln p_i \quad \& \quad g_k = \left(\frac{1-\alpha_i}{q_{ij}^{h} + \gamma_i}\right)$$

Data

- Household-level panel scanner data (Nielsen)
- New York State, for 1/2005-12/2006
- Unbalanced panel with 2,126 purchase occasions of N = 44
- Six apple varieties
  - Golden Delicious
  - Granny Smith
  - Gala
  - McIntosh
  - Others

Data

	Golden Delicious	Granny Smith	Red Delicious	McIntosh	Gala	Others
Price paid ($/lb)	1.18	1.3	1.18	0.99	1.32	1.15
Quantity (lbs)	2.18	1.93	1.98	2.64	1.91	2.71
Percent sold on Promotion	19.08	13.43	40.53	28.26	30	27.46
Percent Organics	14.13	15.42	16.52	2.54	10.7	7.29
Percent Bagged	1.41	1.41	3.08	6.16	6.28	9.72
Number of Purchase Occasions	283	201	454	276	430	823
Soluble Solids (%) (sweetness)	13.5	12.7	13.2	13.4	13.3	13.2
Acidity (%) (tartness)	0.4	0.58	0.22	0.32	0.33	0.37
Firmness (lbs. per ft.) (texture)	13.4	16.5	15.6	15.3	14.6	15.1

Data

- Incidence of demand for variety

# of Varieties	# of Obs	%
1	1848	86.5
2	254	11.9
3	26	1.2
4	7	0.3
5	1	0.1

Results

	MDCEV			Logit		
	Variety	Category	Total	Variety	Category	Total
Granny Smith	59.10%	40.90%	38.56%	48.30%	51.70%	0.80%
Red Del.	56.90%	43.10%	68.44%	82.50%	17.50%	1.84%
McIntosh	53.20%	46.80%	67.31%	81.40%	18.60%	4.47%
Gala	53.70%	46.30%	77.92%	82.40%	17.60%	2.95%
Others	50.10%	49.90%	23.25%	81.60%	18.50%	1.64%
RMSE			0.76			0.95
Theil's U			0.01			0.01

Conclusions

- We need to be careful about how we estimate price promotion effectiveness
- We must pay attention to how consumers shop a category and how the nature of data
- Modeling assumptions can make a huge difference
- Serious managerial implications
- MDCEV model should be utilized in future price promotion research…with limits
  - Computationally difficult
  - Complex elasticity structure

Thank You!