Modeling Dynamics in Buying Behavior

MS Seminar

Is This Model Dynamic?

$$U_{ijt} = \alpha_j - \beta_1 price_{ijt} + \beta_2 adv_{ijt} + \beta_3 display_{ijt} + \varepsilon_{ijt}$$

Individual i
Brand j
Time t

$$P(choice_{it} = j) = \frac{\exp(V_{ijt})}{\sum_j \exp(V_{ijt})}$$

Sources of Dynamics

Exogenous Sources	Endogenous Sources

Reminder: Capturing Heterogeneity

$$U_{ijt} = \alpha_{ij} - \beta_{i1} price_{ijt} + \beta_{i2} adv_{ijt} + \beta_{i3} display_{ijt} + \varepsilon_{ijt}$$

<u>Possible Methods:</u>

Latent Class Models/ Finite Mixture Models

Simulated Maximum Likelihood

Hierarchical Bayes

State Dependence

Learning - Loyalty - State dependence

$$U_{ijt} = \alpha_{ij} - \beta_1 price_{ijt} + \beta_2 adv_{ijt} + \beta_3 display_{ijt} + f(Y_{it=1},\ldots,Y_{it-1}) + \varepsilon_{ijt}$$

For example:

State dependence $\beta_4 Y_{ijt-1}$

Loyalty $\beta_4 LOY_{ijt}$ $LOY_{ijt} = \lambda Y_{ijt-1} + (1-\lambda) LOY_{ijt-1}$

What does the state dependence term capture?

References:

Heckman (1981); Guadagni and Little (1983, MS); Roy Chintagunta and Halder (1996, MS); Keane (1997, JBES), Seetharaman et al. (1999, MS);

State Dependence - Example

	1	2	3	4	5	6	7	8	9	10
Customer 1 P=0.1	0	0	0	1	0	0	0	0	0	0
Customer 2 P=0.5	0	1	1	0	1	0	0	1	0	1
Customer 3 P=0.5	0	0	0	0	0	1	1	1	1	1
Customer 4 P=0.9	1	1	0	1	1	1	1	1	1	1

State Dependence

Learning - Loyalty - State dependence

$$U_{ijt} = \alpha_{ij} - \beta_1 price_{ijt} + \beta_2 adv_{ijt} + \beta_3 display_{ijt} + f(Y_{it=1},\ldots,Y_{it-1}) + \varepsilon_{ijt}$$

- Likelihood function
- Estimation
- Correlation in the errors
- Initial conditions problem
- Lagged independent variables

Variety Seeking

$$U_{ijt} = \alpha_j - \beta_1 price_{ijt} + \beta_2 adv_{ijt} + \beta_3 display_{ijt} + f(VS_{ij}(history)) + \varepsilon_{ijt}$$

References:
McAlister and Pessemier (1982, JCR); Kahn et al. (1986, JMR); Bawa (1990, MS);

Autoregressive models

Autoregressive Models

$$U_{ijt} = \alpha_j - \beta_1 price_{ijt} + \beta_2 adv_{ijt} + \beta_3 display_{ijt} + \varepsilon_{ijt}$$

$$\varepsilon_{ijt} = \rho\varepsilon_{ijt-1} + \nu_t, \quad \nu_{ijt} \sim N(0,\sigma^2)$$

Estimation?

$$\Sigma = \begin{bmatrix} \sigma^2 & \rho\sigma^2 & & \\ \rho\sigma^2 & \sigma^2 & \rho\sigma^2 & \\ & \rho\sigma^2 & \sigma^2 & \rho\sigma^2 \\ & & \rho\sigma^2 & \sigma^2 \end{bmatrix}$$

References:

Keane (1997, JBES), Allenby and Lenk (1994, JASA), Paap and Franses (2000, JAE)

Vector Auto-Regressive

VAR-X Models

- Vector cousin of the state dependence model

$$\begin{bmatrix} Y_{1t} \\ Y_{2t} \\ \vdots \\ Y_{Jt} \end{bmatrix} = \sum_{k=1}^{K} \begin{bmatrix} & & \\ & \Lambda_k & \\ & & \end{bmatrix} \begin{bmatrix} Y_{1,t-k} \\ Y_{2,t-k} \\ \vdots \\ Y_{N,t-k} \end{bmatrix} + \begin{bmatrix} \beta_{1,1} & \cdots & \beta_{1,k} \\ & \ddots & \\ \beta_{J,1} & \cdots & \beta_{J,k} \end{bmatrix} \begin{bmatrix} x_{1,t} \\ \vdots \\ x_{k,t} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \vdots \\ \varepsilon_{Jt} \end{bmatrix}$$

References:

Dekimpe et al. (1999, JE), Bronnenberg et al. (2000, JMR), Nijs et al. (2001, Mktg, Sci.), Pauwels et al. (2002, JMR), Srinivasan et al. (2004, Mgmt. Sci.)

Forward Looking Models

Forward Looking Consumers

- When consumer's decisions today are dependent on the consumer's expectations about the future
- The consumer maximizes the expected present value flow of discounted utilities.

Examples:

- Quality expectations (e.g., Erdem and Keane 1996)
- Sale-force compensation expectations (e.g., Misra and Nair 2009)
- Technology adoption (e.g., Gordon 2009)
- Promotion and coupon expectation (e.g., Gönül and Srinivasan 1996; Erdem, Imai, Keane 2003)
- Product launch (e.g., Hitsch 2006)

Forward Looking Models

$$V_{it} = E\left[\sum_{t=1}^{\infty} \beta^t \sum_{j=1}^{J} U_{ijt|S_{it}}\right]$$

Could be our standard additive utility function

Need expectations over s_t

This expression could be simplified using the Bellman equation

$$\max_{y_t} V_{it} = U_{ijt|s_{it}} + \beta E[V_{it+1}(S_{it+1})]$$

The Bellman Equation has a unique solution (contraction mapping)

Forward Looking Models

Difficulties:

- Need to define the expectations
- State space can become large
- Discount factor often cannot be estimated
- Estimation
- Heterogeneity