Modeling Dynamics in Buying Behavior

MS Seminar

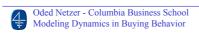


Is This Model Dynamic?

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

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



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Reminder: Capturing Heterogeneity

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

Possible Methods:

Latent Class Models/ Finite Mixture Models Simulated Maximum Likelihood **Hierarchical Bayes**



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State Dependence

Learning - Loyalty - State dependence

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

For example:

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

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

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);



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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



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State Dependence

Learning - Loyalty - State dependence $U_{ijt} = \alpha_{ij} - \beta_1 price_{ijt} + \beta_2 adv_{ijt} + \beta_3 display_{ijt} + f(Y_{u=1},...,Y_{u-1}) + \varepsilon_{ijt}$

- 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

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

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

Estimation?
$$\Sigma = \begin{bmatrix} \sigma^2 & \rho \sigma^2 \\ \rho \sigma^2 & \sigma^2 & \rho \sigma^2 \\ \rho \sigma^2 & \sigma^2 & \rho \sigma^2 \\ \rho \sigma^2 & \sigma^2 & \rho \sigma^2 \end{bmatrix}$$
References:
$$\rho \sigma^2 = \begin{bmatrix} \sigma^2 & \rho \sigma^2 \\ \rho \sigma^2 & \sigma^2 \\ \rho \sigma^2 & \sigma^2 \end{bmatrix}$$

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



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Vector Auto-Regressive

VAR-X Models

· Vector cousin of the state dependence model

$$\begin{bmatrix} Y_{1t} \\ Y_{2t} \\ M \end{bmatrix} = \sum_{k=1}^{K} \begin{bmatrix} & & & \\ & Y_{1,t-k} \\ & & \\ & & \end{bmatrix} \begin{bmatrix} Y_{1,t-k} \\ Y_{2,t-k} \\ & M \end{bmatrix} + \begin{bmatrix} \beta_{1,1} & L & \beta_{1,k} \\ & & \\ &$$

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.)



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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

