Consumers Emotional Impact to Shopping Behavior: Joint Modeling of Shopping Amount and Intervals

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"Is your purchase behavior rational?"

Research Objectives and Approach

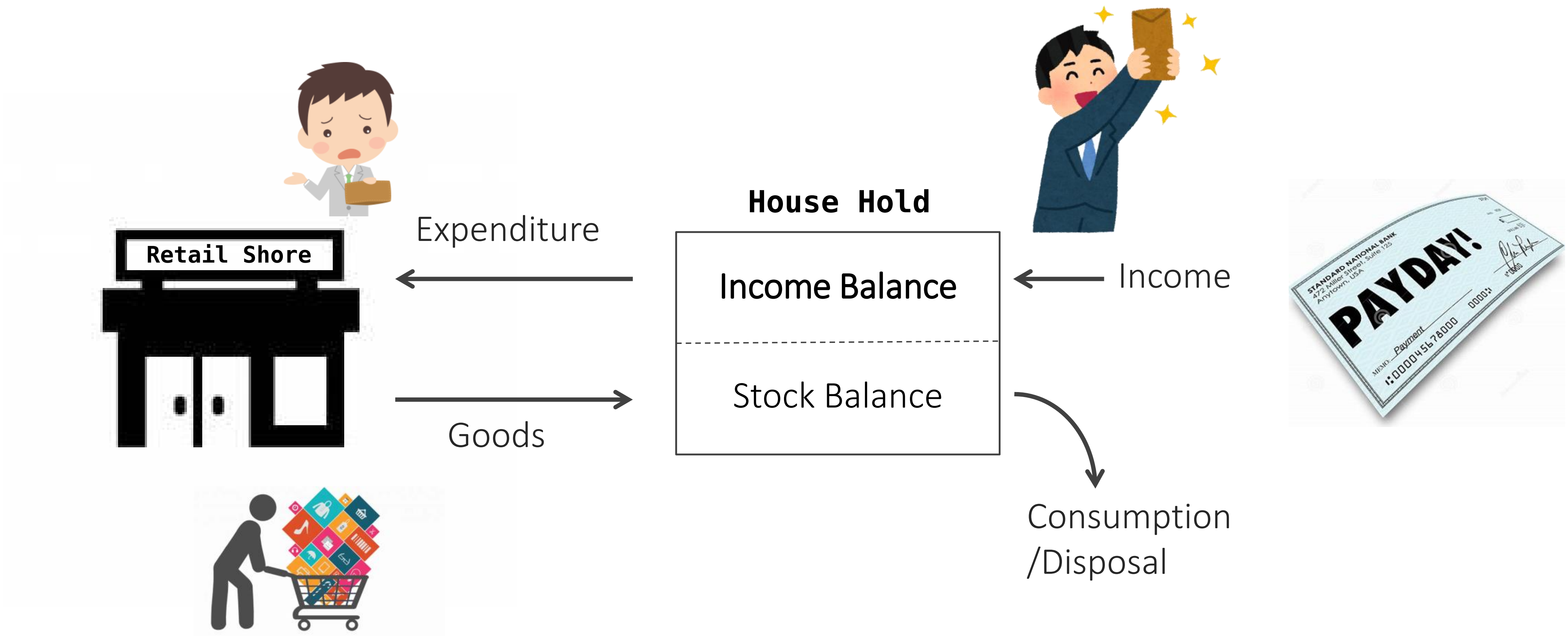
Objectives

- Understand how consumer purchase behaviors change depending of individual's mental condition and find out marketing implications through these changes for retailers

Approach

- Model consumer behaviors with Hierarchical Bayesian method combined with mental accounting reference model ("mental loading") to capture a change point and different regime structures

Mental Conditions at Purchase

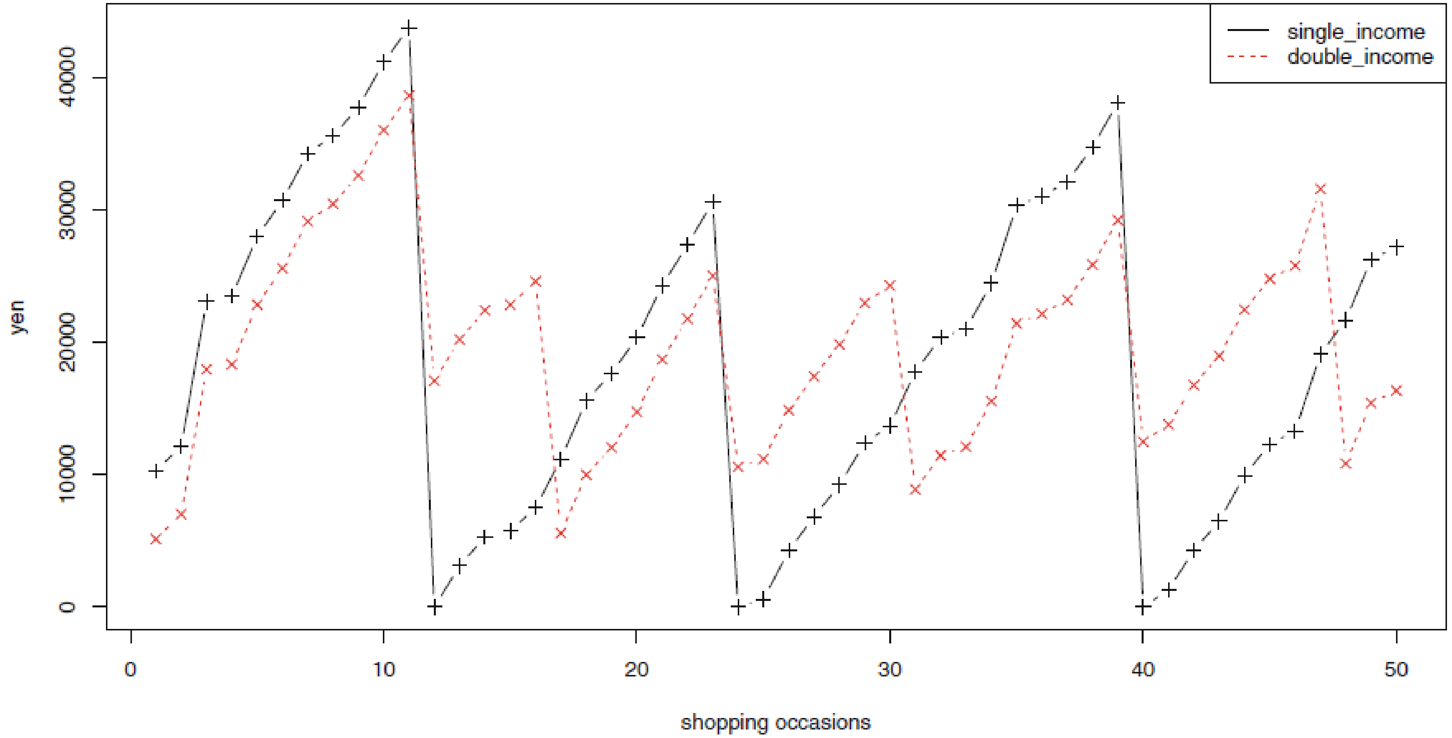


Mental Loading

Cumulative spend from payday(s), which implies degree of consumer's mental pressure at purchase

$$CummM_{i,t_i} = \alpha_i^{*(1)} cumm_{i,t_i,1} + \alpha_i^{*(2)} cumm_{i,t_i,2} + \alpha_i^{*(3)} cumm_{i,t_i,3}$$

Example)



$$cumm_{i,t_i,l} = \begin{cases} \sum_{j=1}^{trans^l(t_i)-1} (M_{i,j}) \\ 0 \quad \text{the first time after a payday} \end{cases}$$

$$0 \leq \alpha_i^{*(k)} \leq 1 \text{ and } \sum_{k=1}^{3} \alpha_i^{*(k)} = 1$$

$l = 1 \Rightarrow$ mm/25th – (mm+1)/24th

$l = 2 \Rightarrow$ mm/ 5th – (mm+1)/ 4th

$l = 3 \Rightarrow$ mm/17th – (mm+1)/16th

Previous Studies of Mental Accounting Modeling

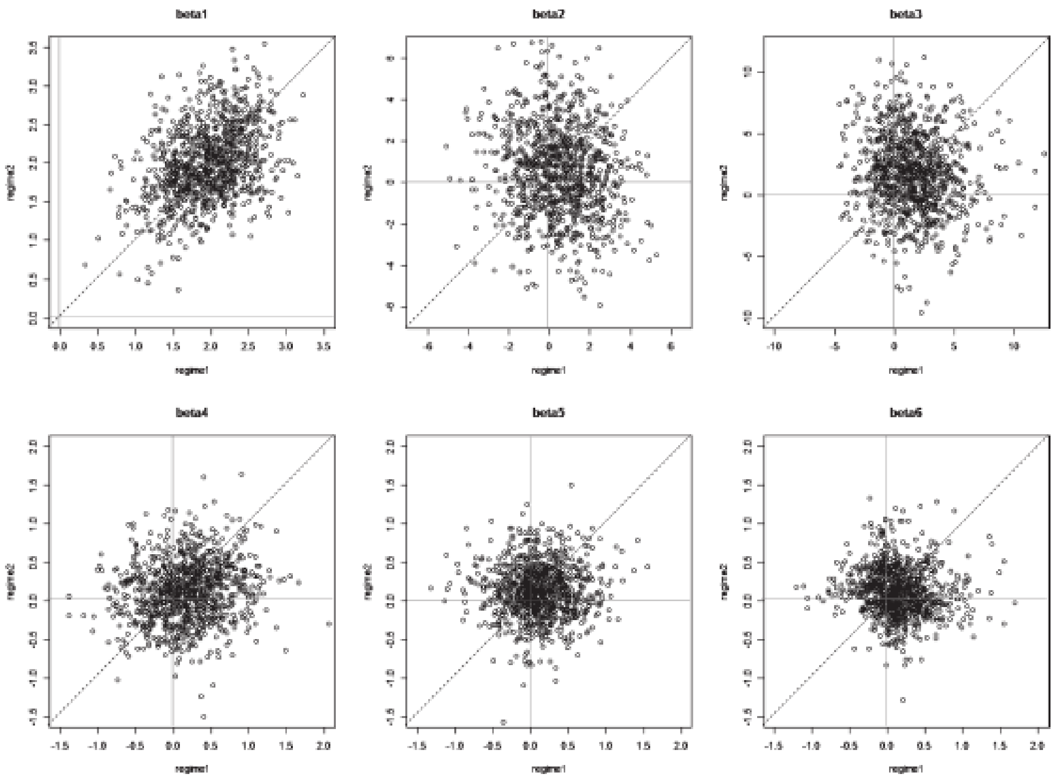


図 5.　各係数 $(\beta^{(1)}, \beta^{(2)})$ の分布

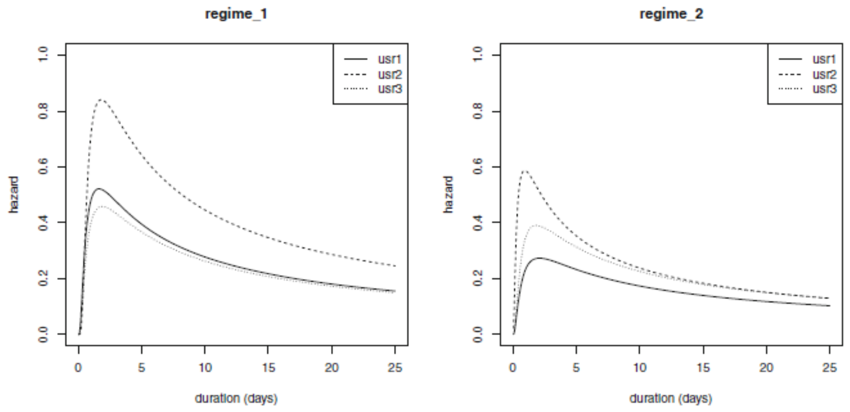


Fig. 5. Hazard (a Double-Regime Occupant)

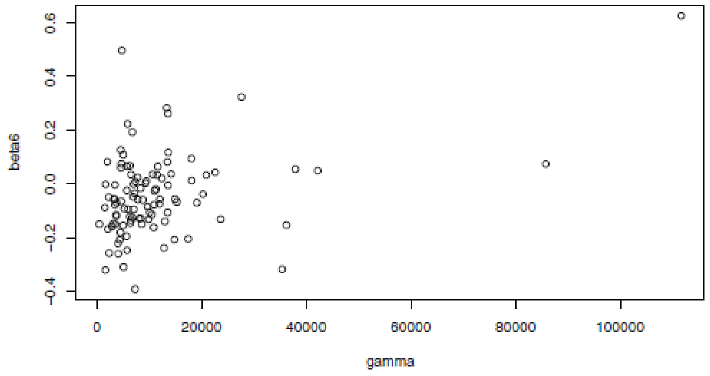
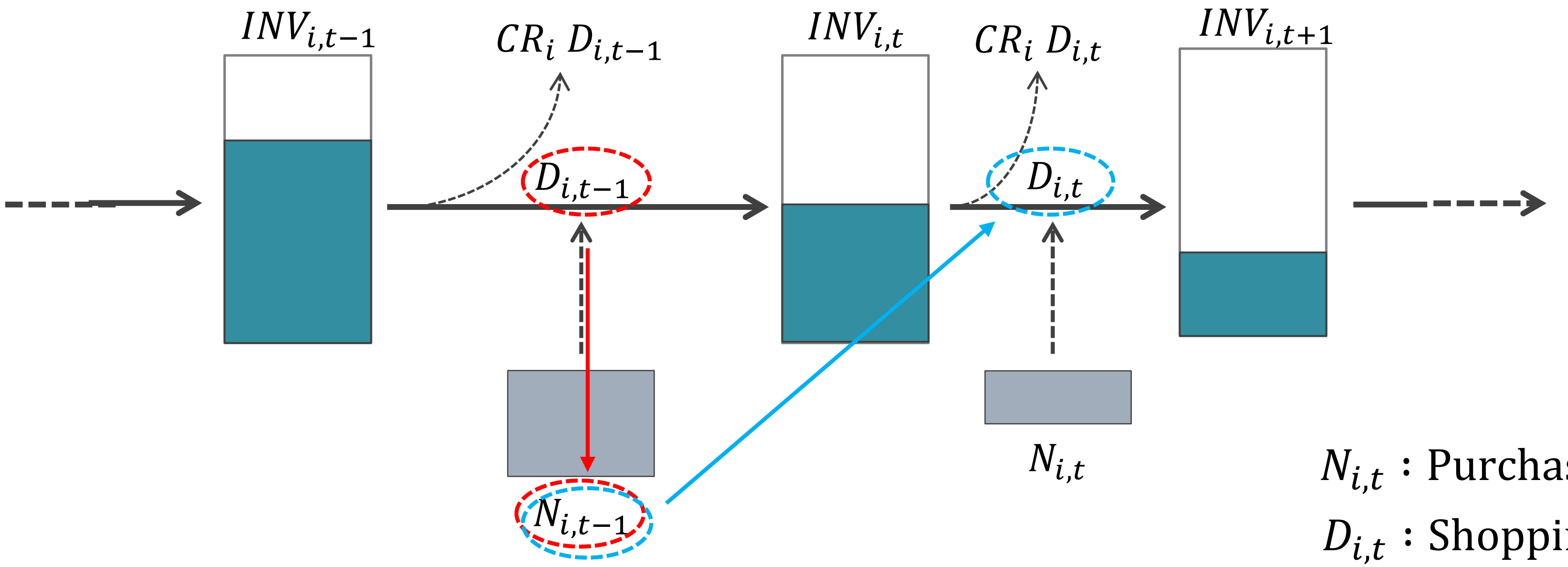


Fig. 3. Scatter plots $(\gamma_{cum} - \beta_6)$

“Modeling of Relationship between Mental Accounting and Purchase Behavior”
Kazuhiro Miyatsu and Tadahiko Sato, Japanese J. Appl. Statist. 44(3) (2015), 161-182

“Modeling the Heterogeneous Mental Accounting Impact to Inter-shopping Duraiton”
Kazuhiro Miyatsu and Tadahiko Sato,, KSS 2018, CCIS 949, 1-16 2018

Purchase Amount and Shopping Interval



$N_{i,t}$: Purchase Amount at t for i

$D_{i,t}$: Shopping Interval at t for i

$$INV_{i,t} = INV_{i,t-1} + N_{i,t-1} - CR_i\ D_{i,t-1}$$ (Bucklin and Lattin 1991)

Joint Modeling of Purchase Amount and Interval

For consumer (i) , we assume purchase amount ($\boldsymbol{n}_{i,t}$) has dependency on shopping interval ($\boldsymbol{d}_{i,t}$), and shopping interval ($\boldsymbol{d}_{i,t}$) on purchase amount at the previous shopping occasion ($\boldsymbol{n}_{i,t-1}$).

$$f_i(n_{i,t}, d_{i,t} \mid \boldsymbol{n}_{i,1:t-1}, \boldsymbol{d}_{i,1:t-1}) = g(n_{i,t} | d_{i,t}) h(d_{i,t} | n_{i,t-1})$$

$$\begin{cases} n_{i,t} \sim Poisson(\lambda_{i,t}) & : \text{purchase amount at } t \text{ for } i \\ d_{i,t} \sim LogNormal(\mu_{i,t}, \sigma_i^2) & : \text{shopping interval at } t \text{ for } i \end{cases}$$

$\lambda_{i,t}$ and $\mu_{i,t}$ have the following linear structure with explanatory variables $\boldsymbol{x}_{i,t}$ *and* $\boldsymbol{y}_{i,t}$;

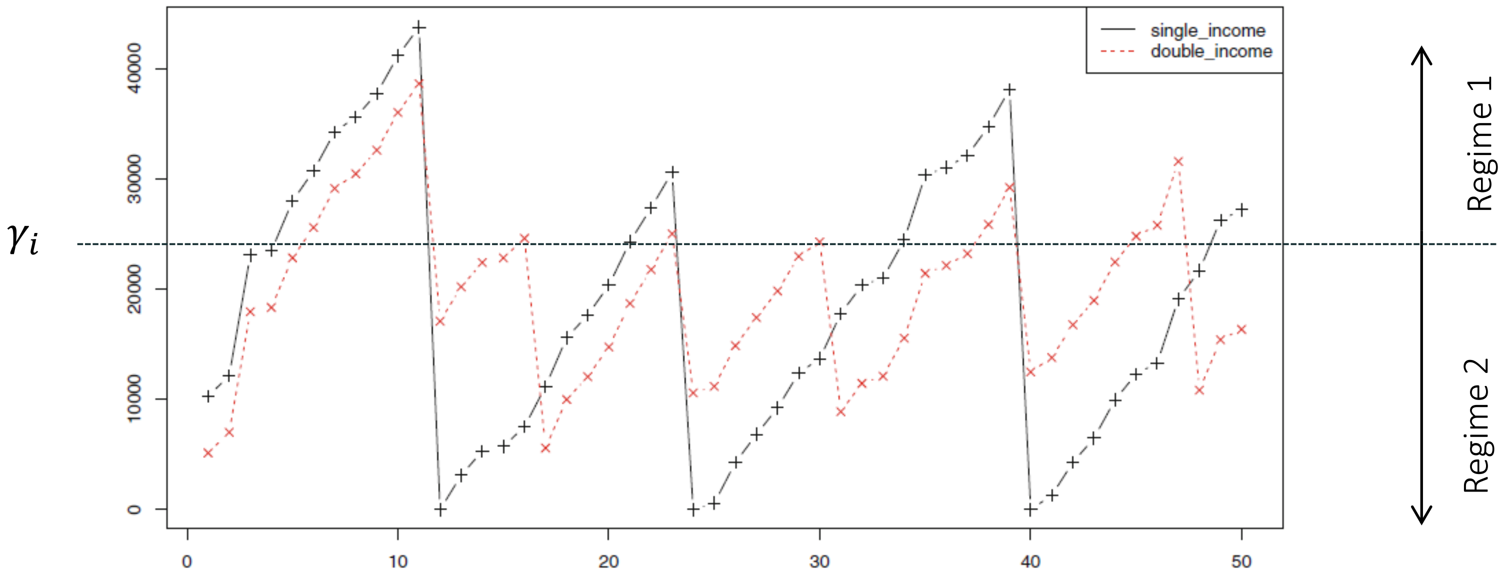
$$\begin{cases} \ln \lambda_{i,t} = \boldsymbol{x}_{i,t}^t \, \boldsymbol{\alpha}_i & \boldsymbol{x}_{i,t} = (x_{i,t}^{(1)}, x_{i,t}^{(2)}, \cdots, d_{i,t})^t, & \boldsymbol{\alpha}_i = (\alpha_i^{(1)}, \alpha_i^{(2)} \cdots, \alpha_i^{(d)})^t \\ \mu_{i,t} = \boldsymbol{y}_{i,t}^t \, \boldsymbol{\beta}_i & \boldsymbol{y}_{i,t} = (y_{i,t}^{(1)}, y_{i,t}^{(2)}, \cdots, n_{i,t-1})^t, & \boldsymbol{\beta}_i = (\beta_i^{(1)}, \beta_i^{(2)} \cdots, \beta_i^{(n)})^t \end{cases}$$

Joint Modeling with Mental Loading

$$\Pr(n_{i,t}, d_{i,t} | \boldsymbol{x}_{i,t}^{(1)}, \boldsymbol{y}_{i,t}^{(1)}, \boldsymbol{\alpha}_{i}^{(1)}, \boldsymbol{\beta}_{i}^{(1)}, \boldsymbol{x}_{i,t}^{(2)}, \boldsymbol{y}_{i,t}^{(2)}, \boldsymbol{\alpha}_{i}^{(2)}, \boldsymbol{\beta}_{i}^{(2)}, \gamma_i, \sigma_i^{2(1)}, \sigma_i^{2(2)}, CummM_{i,t})$$

$$= \begin{cases} g(n_{i,t} | \boldsymbol{x}_{i,t}^{(1)}, \boldsymbol{\alpha}_{i}^{(1)}) h(d_{i,t} | \boldsymbol{y}_{i,t}^{(1)}, \boldsymbol{\beta}_{i}^{(1)}, \sigma_i^{2(1)}), & CummM_{i,t} \geq \gamma_i \quad (Regime\ 1) \\ g(n_{i,t} | \boldsymbol{x}_{i,t}^{(2)}, \boldsymbol{\alpha}_{i}^{(2)}) h(d_{i,t} | \boldsymbol{y}_{i,t}^{(2)}, \boldsymbol{\beta}_{i}^{(2)}, \sigma_i^{2(2)}), & CummM_{i,t} < \gamma_i \quad (Regime\ 2) \end{cases}$$

Example)



Empirical Analysis

- Objective Market
  - Grocery (fresh food, non-fresh food, and general merchandise)
  - Located in the Greater Tokyo area
- Scanner Panel Data with Customer ID
  - 24 months (2 years) of 2001.Jan - 2002.Dec.
  - N=500 customers
    - at least 1 shopping occasion per month
    - shopping intervals < 30 days
    - not more than 50 items per shopping
- Average Shopping Behavior
  - 12.9 items purchased per shopping occasion
  - 2.13 days between shopping occasions
  - 2,565 JPY spent per shopping occasion
- For 20,000 MCMC iterations, the last 2,000 samples for each consumer were collected for analysis.

Explanatory Variables and Consumer Attribute

$$n_{i,t} \sim Poisson(\lambda_{i,t})$$

$$\ln \lambda_{i,t} = \boldsymbol{x}_{i,t}^{t}\, \boldsymbol{\alpha}_i$$

$\boldsymbol{Cnst}_{i,t}$: $Constant$

$\boldsymbol{Disc}_{i,t}$: $Average\ discount\ rate\ for\ non\ perishable\ items$

$\boldsymbol{Ndis}_{i,t}$: $The\ number\ of\ displayed\ items$

$\boldsymbol{D}_{i,t}$: $Duration\ since\ the\ previous\ occasion$

$$d_{i,t} \sim LogNormal(\mu_{i,t}, \sigma_i^2)$$

$$\mu_{i,t} = \boldsymbol{y}_{i,t}^{t}\, \boldsymbol{\beta}_i$$

$\boldsymbol{Cnst}_{i,t}$: $Constant$

$\boldsymbol{Disc}_{i,t}$: $Average\ discount\ rate\ for\ non\ perishable\ items$

$\boldsymbol{Nflr}_{i,t}$: $The\ number\ of\ items\ on\ flyer$

$\boldsymbol{N}_{i,t-1}$: $The\ number\ of\ items\ at\ the\ previous\ occasion$

Attributes for Hierarchical Bayesian

$$\boldsymbol{z}_i$$

$\boldsymbol{Avyen}_i$: $Average\ amount\ spent\ per\ shopping$

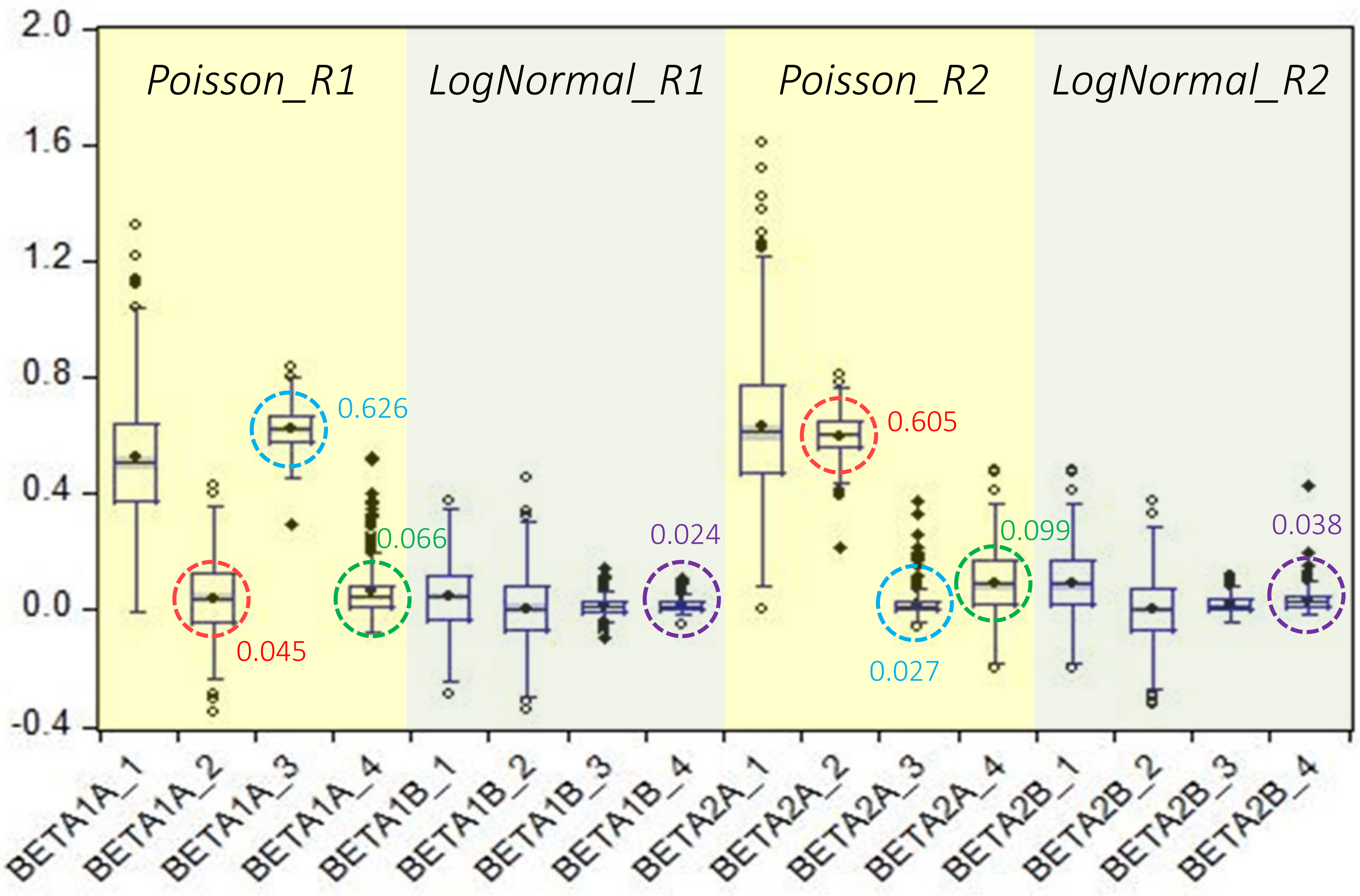
$\boldsymbol{Work}1_i$: $Average\ discount\ rate\ for\ non\ perishable\ items$

$\boldsymbol{Work2}_i$: $The\ number\ of\ items\ on\ flyer$

$\boldsymbol{Work3}_i$: $The\ number\ of\ items\ at\ the\ previous\ occasion$

$\boldsymbol{Foot}_i$: $The\ number\ of\ items\ at\ the\ previous\ occasion$

Box Plots of Coefficients at Different Regimes



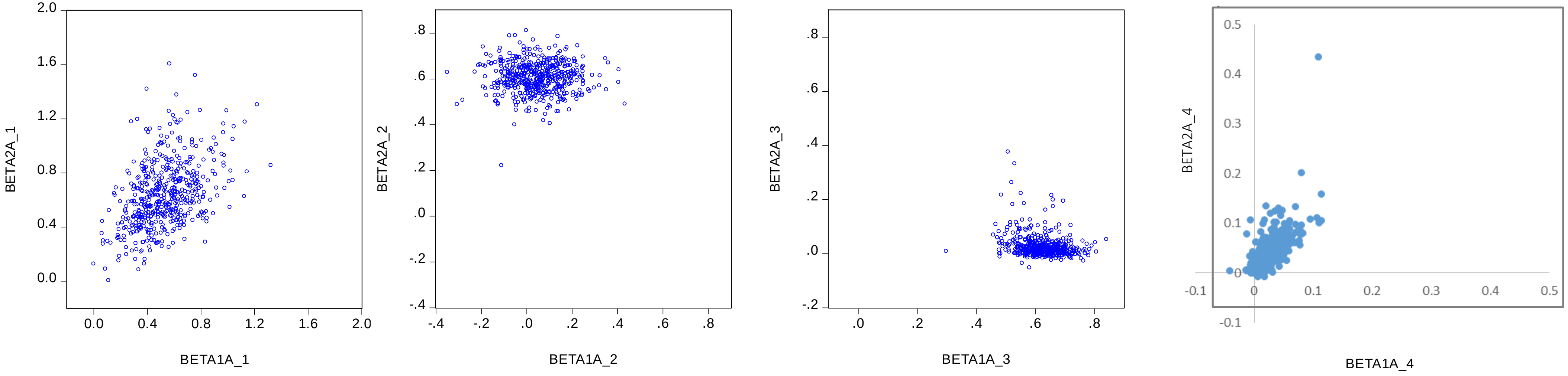
$$\frac{\beta^{R1}_{LogNormal,4}}{\beta^{R1}_{Poisson,4}} = 0.355$$

$$\wedge$$

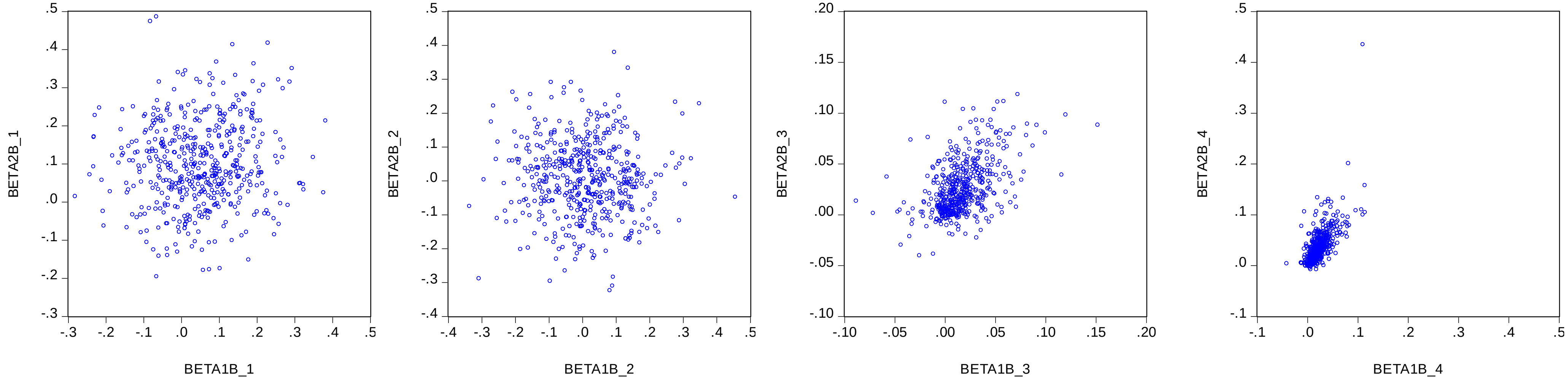
$$\frac{\beta^{R2}_{LogNormal,4}}{\beta^{R2}_{Poisson,4}} = 0.382$$

Scatter Plots of Coefficients at Different Regimes

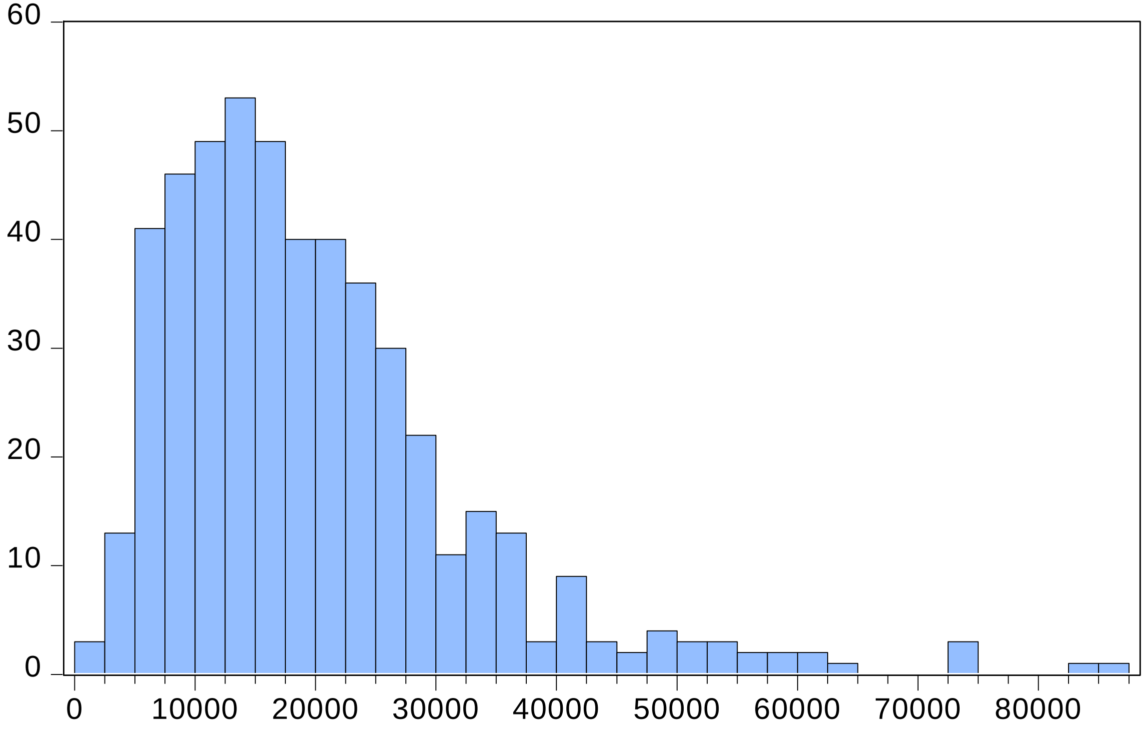
Poisson



LogNormal



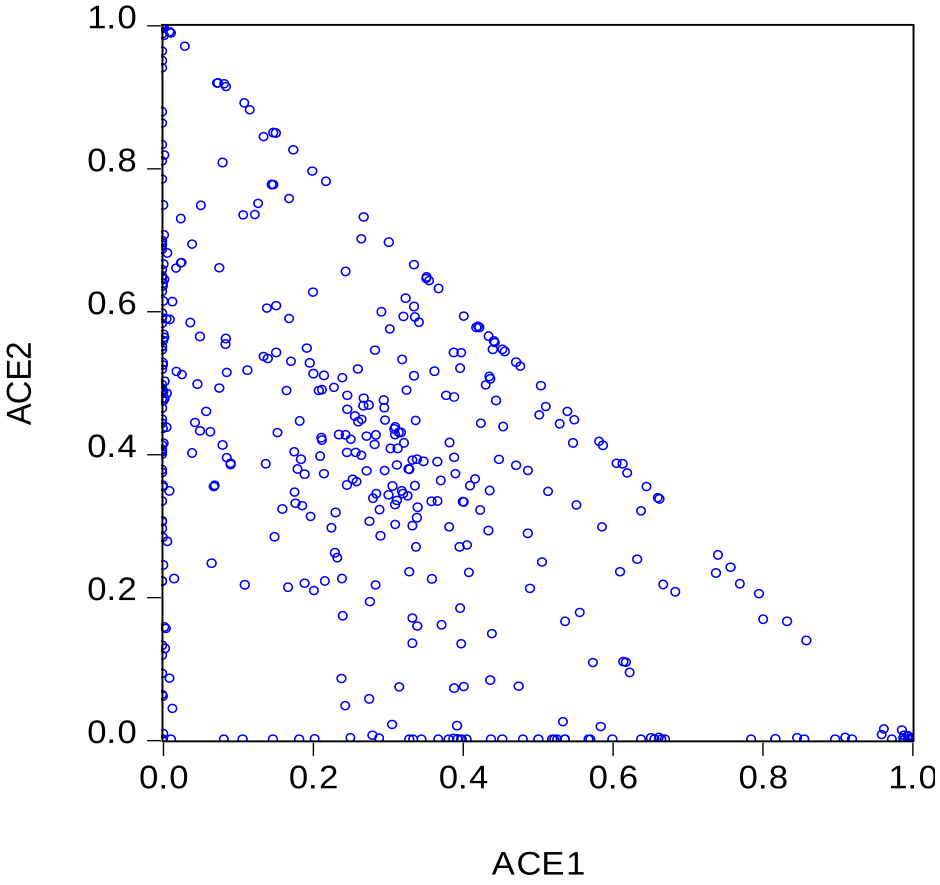
Threshold Parameter Estimation



Series: GAMMA
Sample 1 500
Observations 500

Mean	20004.80
Median	17222.16
Maximum	85789.91
Minimum	611.8816
Std. Dev.	12805.83
Skewness	1.693735
Kurtosis	7.290457
Jarque-Bera	622.5620
Probability	0.000000

Mental Loading Structure Estimation



Weight Parameters	Occupancy (%)
α_1	7.6%
α_2	7.6%
α_3	1.2%
α_1, α_2	9.6%
α_2, α_3	16.8%
α_3, α_1	9.2%
α_1, α_2, α_3	48.0%

Direct Effect of Mental Loading

Poisson_R1	*LogNormal_R1*	*Poisson_R2*	*LogNormal_R2*	DIC
				1,413,135
			✓	1,459,115
		✓		1,399,180
		✓	✓	1,467,105
	✓			1,419,965
	✓		✓	1,574,395
	✓	✓		1,412,475
	✓	✓	✓	1,416,741
✓				1,401,592
✓			✓	1,406,864
✓		✓		1,408,525
✓		✓	✓	1,392,880
✓	✓			1,408,459
✓	✓		✓	1,405,267
✓	✓	✓		1,400,636
✓	✓	✓	✓	1,404,283

Poisson_R1: Poisson distribution in regime1
Poisson_R2: Poisson distribution in regime2

LogNormal_R1: LogNormal distribution in regime1
LogNormal_R2: LogNormal distribution in regime2

✓ indicates "*mental loading*" is included to measure its indirect impact as explanatory variable for λ and/or μ in Poisson and LogNormal distributions respectively in the following form:

$$x_{i,5} = \ln(\frac{CummM_{i,t}}{1{,}000} + 0.0001)$$

Summary and Further Studies

- Marketing such as discount and display becomes less effective when consumer feels more pressure in spending esp. for amount to purchase.
- The previous shopping experience, i.e. amount purchased and interval, becomes less memorable when consumer feels more pressure in spending.
- Consumers' shopping behavior is more influenced by how much they purchased at the previous occasion rather than when they went for shopping last time.
- Accommodating heterogeneity of direct mental loading effect in the joint modeling at individual level is further study.