Rational Inattention and Consumer Benefits from New Products Based on Market Share Data

Yulin Hao

Research Proposal

November 11, 2019

Motivations

Producing more goods does not necessarily improve consumers' welfare

- field experiments evidence: Iyengar et al. (2004), Bertrand et al. (2010)
- consumers face uncertainly about product attributes, but too costly to remove all uncertainty
- may enjoy less benefit than expected

Research question: whether and how much consumers benefit from new products under imperfect information

- key challenge is how to estimate a realistic demand
  - traditional demand estimation framework doesn't work, Why?
  - micro-foundation is utility maximization: consumers better off more or less
- maybe we need a new micro-foundation for discrete choice models

What this paper is trying to do

Incorporate rational inattention into demand estimation using market share data, and then measure consumer welfare change from new product introductions

- rational inattention is pioneered by sims (2003) in macroeconomics
- combine psychological insights into optimizing framework
- optimal solution follows modified logit form (Matejka and McKay, 2015). Alternative micro-foundation for choice models
- difference between RI logit and traditional logit model (McFadden, 1974): includes biases driven by prior beliefs about payoffs of alternatives

Rational inattention in marketing settings

Consumers are rationally inattentive

- before making a purchase, consumers have a prior belief over products
- pay attention to acquire information, e.g. read product reviews
- after observing signals, update their beliefs, yield posterior distribution. The choice probability after the costly information acquisition has an extended-logit form

RI framework is

- theoretically,
  - $+$ attractive, integrate information frictions into discrete choice models
- empirically,
  - $+$ only need market level data
    - ⋆ current studies incorporating information friction into demand estimation rely on consumer level data (Morozov, 2019)
  - $-$ how to make RI-logit model empirically tractable is challenging

Why this research is important

Managerial implications

- consumers do not always benefit from product innovations because consumers are rationally inattentive.
- importance of shaping consumers' prior beliefs. a subtle change of beliefs can lead to large shifts in consumer behavior.

Contributions to existing literature:

- (pure) characteristics demand estimation. Specifically, measure consumers surplus from new goods. Petrin (2002, JPE), Song (2007, Rand).
- rational inattention literature. Advance empirical structural estimation with RI
- modelling consumer behavior using RI framework is promising in marketing

Ideal data

- we need market level data: quantities, prices, and product characteristics. Plus we need distribution of demographics information P_D in each market, and market-product level marketing variables (advertisement, promotions, etc)
- need cross-market variation to identify nonlinear parameters
- Possible market: CPU
- definition of market and outside good, computation of actual market share are data driven

Model

The indirect utility function of good j in market t for consumer i is:

$$u_{ijt} = \alpha_0 + \alpha p_{jt} + X'_{jt}\beta + \xi_{jt}$$

normalize outside good $u_{i0t} = 0$. Unobserved characteristics ξ_{jt} is correlated with price p_{jt}.
no idiosyncratic taste shock included. the randomness is driven by the randomness in choice mistakes due to the noise in signals

Model

Consumer's problem. *The consumer's problem is to find an information strategy maximizing expected utility less the information cost:*

$$\underset{P(ijt|u_{it})}{\text{Max}} \left(\sum_{i=1}^{N} \int_u \sum_{j \in \mathcal{J}} u_{ijt} P(ijt|u_{ij}) G(du) - \lambda \kappa(P, G) \right)$$

where $G(u)$ is the prior belief over u_{itj}, λ is marginal information cost, κ is the information cost function proportional to the expected difference in the generalized entropy of unconditional and conditional choice probabilities:

$$\kappa(P, G) = -\sum_{i=1}^{N} P(ijt) \ln P(ijt) + \int_u \left(\sum_{i=1}^{N} P(ijt|u_{it}) \ln P(ijt|u_{it}) \right) G(du)$$

Model

The solution follows the modified logit formula:

$$P(ijt|u_{it}) = \frac{P(ijt)e^{\frac{u_{ijt}}{\lambda}}}{\sum_{j' \in \mathcal{J}} P(ijt)e^{\frac{u_{ij't}}{\lambda}}} \tag{1}$$

where $P(ijt|u_{it})$ is the individual posterior choice probability, $P(ijt)$ is the prior choice probability before the costly learning.

Model

Refer to Joo (2019), I model consumers' prior belief is affected by product-marketing level marketing variables, e.g. advertisements, promotions. I assume information cost λ is affected by consumer level demographics.
Parametrize $P(ijt) \propto e^{\mathbf{H_t}'\gamma}$. H_t denotes vector of marketing variables. $\frac{1}{\lambda} \propto e^{\mathbf{D_{it}}'\omega}$. D_{it} is the vector of demographics.

$$P(ijt|u_{it}) = \frac{exp\left(\mathbf{h_{jt}}'\omega + \mathbf{d_{ijt}}'\gamma u_{ijt}\right)}{\sum_{j' \in \mathcal{J}} exp(\mathbf{h_{j't}}'\omega + \mathbf{d_{ij't}}'\gamma u_{ij't})}$$

$$= \frac{exp\left(\mathbf{h_{jt}}'\omega + \mathbf{d_{ijt}}'\gamma(\alpha_0 + \alpha p_{jt} + \mathbf{X_{jt}}\beta + \xi_{jt})\right)}{\sum_{j' \in \mathcal{J}} exp\left(\mathbf{h_{j't}}'\omega + \mathbf{d_{ij't}}'\gamma(\alpha_0 + \alpha p_{j't} + \mathbf{X_{j't}}\beta + \xi_{j't})\right)}$$

Estimation

by integrating out over the distribution of d_i in the population, we get market shares for product j in market t:

$$s_{jt} = \int \frac{exp\left(\mathbf{h_{jt}}'\omega + \mathbf{d_{ijt}}'\gamma(\alpha_0 + \alpha p_{jt} + \mathbf{X_{jt}}\beta + \xi_{jt})\right)}{\sum_{j' \in \mathcal{J}} exp\left(\mathbf{h_{j't}}'\omega + \mathbf{d_{ij't}}'\gamma(\alpha_0 + \alpha p_{j't} + \mathbf{X_{j't}}\beta + \xi_{j't})\right)} dF_d(d_i)$$

no close-form solution. Monte Carlo integration or importance sampling

Estimation: Instrument variables

to deal with price endogeneity, need instrumental variables, Z, such than

$$E(\xi_{jt}|Z) = 0$$

I use BLP instrument as an approximation of the optimal instrument set. The instrument matrix is specified as:

$$Z = [x_{jt}, \sum_{r \neq j, \text{same firm}} x_{rt}, \sum_{r \neq j, \text{rival firms}} x_{rt}]$$

Estimation: the MPEC formulation

BLP(1994) is a traditional approach. A more recent method is by writing the GMM problem and setting the market-share system as constraints (Dube et al., 2012). Then the problem is:

$$\text{Max}\, g(\xi,\beta)' W g(\xi,\beta)$$

$$\text{s. t. } s_{jt} = \int \frac{exp\left(\mathbf{h_{jt}}'\omega + \mathbf{d_{ijt}}'\gamma(\alpha_0 + \alpha p_{jt} + \mathbf{X_{jt}}\beta + \xi_{jt})\right)}{\sum_{j'\in\mathcal{J}} exp\left(\mathbf{h_{j't}}'\omega + \mathbf{d_{ij't}}'\gamma(\alpha_0 + \alpha p_{j't} + \mathbf{X_{j't}}\beta + \xi_{j't})\right)} dF_d(d_i)$$

Counterfactual analysis

- use compensating variation to measure changes in consumer welfare from new products introduction
  - the amount of money a consumer would be indifferent between the circumstance with the product and the one without the product
- treat existence of the product as ex post scenario. In the counterfactual environment, removing the product from consumers choice set, and there is no product on the market.