# Attentional Complements

Dániel Csaba

New York University

**The 2019 Sloan-Nomis Workshop on the Cognitive Foundations of Economic Behavior**

February 22, 2019

# Introduction

**Object of study:** demand system shaped by costly information acquisition.

- Information either about the available alternatives or about how we value them.

# Introduction

**Object of study:** demand system shaped by costly information acquisition.

- Information either about the available alternatives or about how we value them.

**Framework:** static discrete choice rational inattention model under flexible information costs.

# Introduction

**Object of study:** demand system shaped by costly information acquisition.

- Information either about the available alternatives or about how we value them.

**Framework:** static discrete choice rational inattention model under flexible information costs.

**Questions:**

- How are elasticity patterns with respect to a generic improvement in an alternative shaped by scarce attention?
- How can we estimate such a demand system from standard observational choice data?

# Importance and Context

Most prevalent tool for demand estimation is the random utility model.

- By assumption decision maker has perfect information about both available alternatives and own preferences at the time of decision.
- Important implications for comparative statics serving policy analysis.

# Importance and Context

Most prevalent tool for demand estimation is the random utility model.

- By assumption decision maker has perfect information about both available alternatives and own preferences at the time of decision.
- Important implications for comparative statics serving policy analysis.

Rational inattention model endogenizes the stochastic structure of choice relative to the choice set.

- Reference dependent choice [Woodford, 2012].
- Violation of monotonicity [Matějka and McKay, 2015].
- Endogenous formation of consideration sets [Caplin, Dean, Leahy, 2018].

# Problem and Notation

**Rational Inattention Problem**

$$P^* \in \arg \max_{P \in \mathcal{M}(\Omega)} \left\{ \sum_s \left( \max_{a \in A} u_a \cdot \gamma^s \right) P_\mu(s) - \sum_s \phi\left(\gamma^s\right) P_\mu(s) \right\}$$

- $P \colon \Omega \to \Delta(S)$ is an information structure, $\mu$ is a prior, $\gamma^s$ is a posterior
- $P_\mu$ is the unconditional—prior weighted—probability over signals
- $u_a \in \mathbb{R}^\Omega$ vector of payoffs under alternative $a$
- $A$ set of available alternatives
- $\phi$ is a convex function defining a posterior separable cost function

Optimal information structure $P^*$ defines choice probabilities, $\rho^{\mathtt{RI}}(a, A)$.

# Comparative Statics

Choice probabilities derived within the rational inattention model define individual level demand system.

# Comparative Statics

Choice probabilities derived within the rational inattention model define individual level demand system.

How does the unilateral improvement in an alternative affect the demand system?

- Change in demand for alternative $b$ from choice set A as utility of $a$ in state $\omega$ improves:

$$\frac{\partial \rho^{\mathtt{RI}}(b, A)}{\partial u(a, \omega)}$$

# Comparative Statics

Choice probabilities derived within the rational inattention model define individual level demand system.

How does the unilateral improvement in an alternative affect the demand system?

- Change in demand for alternative $b$ from choice set A as utility of $a$ in state $\omega$ improves:

$$\frac{\partial \rho^{\texttt{RI}}(b, A)}{\partial u(a, \omega)}$$

Goods that are substitutes in utility can appear as complements in observed behavior.

$$\frac{\partial \rho^{\texttt{RI}}(a, A)}{\partial u(a, \omega)} > 0 \qquad \text{and} \qquad \frac{\partial \rho^{\texttt{RI}}(b, A)}{\partial u(a, \omega)} > 0$$

# Comparative Statics

**Intuition:**

- Information about the likelihood of an event is valuable in as much as available alternatives' payoffs vary over that event.
- Making the inferior alternative better can render previously useful information useless and hence changing the incentives for what to pay attention to.
- Paying the attention elsewhere implies detecting the occurrence of other events which can increase the demand for other alternatives.

# Comparative Statics

**Intuition:**

- Information about the likelihood of an event is valuable in as much as available alternatives' payoffs vary over that event.
- Making the inferior alternative better can render previously useful information useless and hence changing the incentives for what to pay attention to.
- Paying the attention elsewhere implies detecting the occurrence of other events which can increase the demand for other alternatives.

Experimental evidence supports copmlementarities arising due to endogenous attention allocation.

# Comparative Statics

**Intuition:**

- Information about the likelihood of an event is valuable in as much as available alternatives' payoffs vary over that event.
- Making the inferior alternative better can render previously useful information useless and hence changing the incentives for what to pay attention to.
- Paying the attention elsewhere implies detecting the occurrence of other events which can increase the demand for other alternatives.

Experimental evidence supports copmlementarities arising due to endogenous attention allocation.

**Next steps:** Characterize conditions on payoff matrix and information cost function such that increase in $u(a, \omega)$ leads to increase in $\rho^{\mathtt{RI}}(b, A)$.

# Inference and Estimation

Estimate model of RI from observational data to carry out comparative statics exercise.

# Inference and Estimation

Estimate model of RI from observational data to carry out comparative statics exercise.

Observables of the choice problem:

- $X_{ita}$ – alternative specific, time/market $t$, individual $i$ – $X_{itA}$
- $Z_{it}$ – individual specific, e.g. demographic
- $Y_{it}$ – observed choice

# Inference and Estimation

Estimate model of RI from observational data to carry out comparative statics exercise.

Observables of the choice problem:

- $X_{ita}$ – alternative specific, time/market $t$, individual $i$ – $X_{itA}$
- $Z_{it}$ – individual specific, e.g. demographic
- $Y_{it}$ – observed choice

What is the source of randomness? (linear utility)

$$X_{ita}(\omega)'\beta \qquad \text{or} \qquad X'_{ita}\beta(\omega)$$

# Inference and Estimation

Estimate model of RI from observational data to carry out comparative statics exercise.

Observables of the choice problem:

- $X_{ita}$ – alternative specific, time/market $t$, individual $i$ – $X_{itA}$
- $Z_{it}$ – individual specific, e.g. demographic
- $Y_{it}$ – observed choice

What is the source of randomness? (linear utility)

$$X_{ita}(\omega)'\beta \qquad \text{or} \qquad X'_{ita}\beta(\omega)$$

Conditional or unconditional choice probabilities:

- $X_{ita}(\omega)'\beta \implies$ analyst observes realization of $\omega$
- $X'_{ita}\beta(\omega) \implies$ exact realization of $\omega$ is hidden also for analyst

# Inference and Estimation

Unconditional choice probabilities entail the entire attention strategy.

- Assume information acquisition targets valuation – $X'_{ita}\beta(\omega)$
- Individual covariates affect prior over valuation types – $\mu(Z_{it}, \alpha)(\omega)$

# Inference and Estimation

Unconditional choice probabilities entail the entire attention strategy.

- Assume information acquisition targets valuation – $X'_{ita}\beta(\omega)$
- Individual covariates affect prior over valuation types – $\mu(Z_{it}, \alpha)(\omega)$

Given observed covariates, the choices, $Y_{it}$, are distributed as

$$Y_{it} \mid Z_{it}, X_{itA} \quad \sim \quad \sum_{\omega} \mu(Z_{it}, \alpha)(\omega) P^*_{\omega}\left(Z_{it}, X_{itA}; \alpha, \beta\right)$$

# Inference and Estimation

Unconditional choice probabilities entail the entire attention strategy.

- Assume information acquisition targets valuation – $X'_{ita}\beta(\omega)$
- Individual covariates affect prior over valuation types – $\mu(Z_{it}, \alpha)(\omega)$

Given observed covariates, the choices, $Y_{it}$, are distributed as

$$Y_{it} \mid Z_{it}, X_{itA} \quad \sim \quad \sum_{\omega} \mu(Z_{it}, \alpha)(\omega) P^*_{\omega}\left(Z_{it}, X_{itA}; \alpha, \beta\right)$$

Latent class mixture model with mixture components given by endogenous information structure.

- Number of preference types determined by analyst – number of clusters.

# Inference and Estimation

Local identification of $(\alpha, \beta)$

- fixed information cost function
- stability of individual level consideration sets
- continuity of unconditional choice probability in $(\alpha, \beta)$

# Inference and Estimation

Local identification of $(\alpha, \beta)$

- fixed information cost function
- stability of individual level consideration sets
- continuity of unconditional choice probability in $(\alpha, \beta)$

Estimation strategy robust to endogenous formation of consideration sets.

- Estimation via sampling from quasi-posterior [Chernozhukov and Hong, 2013].

# Inference and Estimation

Local identification of $(\alpha, \beta)$

- fixed information cost function
- stability of individual level consideration sets
- continuity of unconditional choice probability in $(\alpha, \beta)$

Estimation strategy robust to endogenous formation of consideration sets.

- Estimation via sampling from quasi-posterior [Chernozhukov and Hong, 2013].

**Next steps:**

- Identification under joint estimation of utility, prior, and cost parameters.

# Challenges

Discrete choice demand estimation under endogenous information acquisition.

Prove usefulness of RI model for empirical purposes – empirical IO.

# Challenges

Discrete choice demand estimation under endogenous information acquisition.

Prove usefulness of RI model for empirical purposes – empirical IO.

Test whether information frictions play an important role in observational data.

- RUM and RI models are not nested.
- Develop version of RI that nests RUM under no information acquisition.

# Challenges

Discrete choice demand estimation under endogenous information acquisition.

Prove usefulness of RI model for empirical purposes – empirical IO.

Test whether information frictions play an important role in observational data.

- RUM and RI models are not nested.
- Develop version of RI that nests RUM under no information acquisition.

Empirical performance tests.

- Split dataset to estimate both models and run horse-race on out-of-sample prediction.

# Thank You!