Economic Agents as Imperfect Problem Solvers

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Roadmap

Overview

The generic model

Application to consumption/saving

Overview

Different types of behavioral models

$$\mathbb{E}(), u(), \rightarrow a$$

1. Non-FIRE expectations: $\mathbb{E}$
   - Incomplete information, Rational inattention, Learning, Extrapolation, Heterogeneous models
2. Non-standard preferences: u
3. Bounded rationality: $\rightarrow$
   - Non-optimizing behaviors

This paper

- Part 1: General framework
  - Dual-system reasoning [(Kahneman, 2011)]
  - Sometimes, deliberate optimization (system 2)
  - in other times, rule-of-thumb/heuristics (system 1)
  - Intuition: system 2 if state is sufficiently different from the past. system 1 if current state sufficiently resemble the previous state
- Part 2: application in consumption/saving (Aiyagari, 1994)
  - Consumers could get “stuck” in multiple system-1 regions
  - Implication: higher MPC than the standard model

Roadmap

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Application to consumption/saving

The generic model

Generic model

Standard problem

$$V\Bigg(\overbrace{y_t}^{\text{state var}}\Bigg) = \max_{c_t \in B(y_t)} \left[u\left(y_t, c_t\right) + \beta \mathbb{E}_t V\left(y_{t+1}\right)\right]$$

$$y_{t+1} = F\left(y_t, c_t, v_{t+1}\right)$$

$$c^* : Y \to C$$

Modeling dual-system reasoning

Assumption: c^* is costly to obtain, agents only observe noisy signals of it

$$\eta_t = c^*\left(y_t\right) + \underbrace{\sigma_{\eta,t}\varepsilon_t}_{\text{noises}}, \quad \varepsilon_t \sim N(0,1)$$

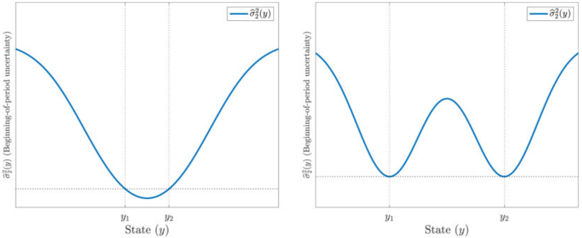
Additional assumption to make things tractable: non-parametric learning

$$c^*(y) = \sum_{j=1}^{\infty} \theta_j \underbrace{\phi_j(y)}_{\text{basis funcs}}$$

Automatic system 1

associative memory

$$\mathbb{E}\left(c^*(y) \mid \eta^{t-1}, y^{t-1}\right)$$



(A) Close-by past signals

(B) Past signals in disparate situations

FIGURE I

Associative Memory and System 1 Uncertainty at Time $t = 3$: $\widehat{\sigma}_2^2(y)$

Plotted based on two signals η_1 and η_2 with equal precision, at state realizations y_1 and y_2.

Occasional deliberate system 2

costly reducing uncertainty about $c^*(y)$

- Invoked only if prior uncertainty $\hat{\sigma}^2_{t-1}(y_t)$ is high enough, exceeds a threshold κ

$$\min_{c_t,\sigma^2_{\eta,t}} \mathbb{E}\left[\left(c_t - c^*(y_t)\right)^2 \mid \eta^t, y^t\right] + \overbrace{\kappa}^{\text{cost of deliberation}} \overbrace{\ln\left(\frac{\widehat{\sigma}^2_{t-1}(y_t) + \sigma^2_{\eta,t}}{\sigma^2_{\eta,t}}\right)}^{\text{information flow}}$$

$$\rightarrow c_t = \hat{c}_t(y_t), \quad \widehat{\sigma}^2_t(y_t) = \min\left[\kappa, \widehat{\sigma}^2_{t-1}(y_t)\right]$$

$$\rightarrow \sigma^{*2}_{\eta,t} = \begin{cases} \frac{\kappa\widehat{\sigma}^2_{t-1}(y_t)}{\widehat{\sigma}^2_{t-1}(y_t)-\kappa}, & \text{if} \quad \widehat{\sigma}^2_{t-1}(y_t) > \kappa, \\ \infty, & \text{if} \quad \widehat{\sigma}^2_{t-1}(y_t) \leqslant \kappa. \end{cases}$$

Action rule from the dual-system

$$c_t = \widehat{c}_t(y_t) = \widehat{c}_{t-1}(y_t) + \alpha_t^*(y_t)\left(\eta_t - \widehat{c}_{t-1}(y_t)\right)$$

$$\alpha_t^*(y_t) \equiv \frac{\widehat{\sigma}_{t-1}^2(y_t)}{\widehat{\sigma}_{t-1}^2(y_t) + \sigma_{\eta,t}^{*2}} = \max\left[1 - \frac{\kappa}{\widehat{\sigma}_{t-1}^2(y_t)}, 0\right]$$

Implications:

- Agents follow default, habitual behavior in familiar situations, but rethink that behavior in novel situations.
- Agents may fall into a learning trap, namely habitual yet non-optimal behaviors when system 1 uncertainty is low enough, and the behaviors lead to self-fulfilling value of state variable.

Roadmap

Overview

The generic model

Application to consumption/saving

Consumption/saving with costly deliberation

Standard problem

[Aiyagari, 1994]

Model

$$V\left(\overbrace{y_{i,t}}^{\text{cash in hand}}\right) = \max_{c_{it}} u\left(c_{i,t}\right) + \beta \mathbb{E}_t V\left(y_{i,t+1}\right)$$

$$y_{i,t+1} = (1+r)\left(y_{i,t} - c_{i,t}\right) + w s_{i,t+1}$$

$$c_{i,t} \leq y_{i,t}$$

This paper

Costly deliberation friction

$$\eta_{i,t} = \overbrace{c^*\left(y_{i,t}\right)}^{\text{optimal c func}} + \varepsilon_{i,t}, \quad \varepsilon_{i,t} \sim N\left(0, \sigma^2_{\eta,i,t}\right)$$

$$\widehat{\sigma}^2_{i,t}\left(y_{i,t}\right) = \min\left[\kappa, \widehat{\sigma}^2_{i,t-1}\left(y_{i,t}\right)\right]$$

$$\widehat{c}_{i,t}\left(y_{i,t}\right) = \widehat{c}_{i,t-1}\left(y_{i,t-1}\right) + \alpha_{i,t}\left(y_{i,t}\right)\left(\eta_{i,t} - \widehat{c}_{i,t-1}\left(y_{i,t-1}\right)\right)$$

$$c_{i,t} = \min\left(y_{i,t}, \widehat{c_{i,t}}\left(y_{i,t}\right)\right)$$

Implications

There are two locally stable learning traps: high-confidence suboptimal consumption policies

1. HtM agents centered around borrowing constraints

$$\bar{y}_i = w \text{ and } \widehat{c}_i(\bar{y}_i) > \overbrace{c^{RW}(\bar{y}_i)}^{\text{Perfect foresight consumption policy}} = \bar{y}_i$$

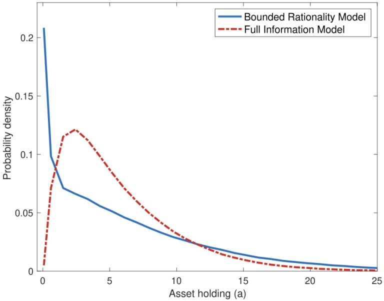
2. Away from borrowing constraint, yet with high MPCs, steeper than perfect-forecast consumption policy

$$\bar{y}_i > w \text{ and } \widehat{c}_i(\bar{y}_i) = c^{RW}(\bar{y}_i) < \bar{y}_i, \frac{\partial \widehat{c}_i}{\partial y}(\bar{y}_i) > \frac{\partial c^{RW}}{\partial y}(\bar{y})$$

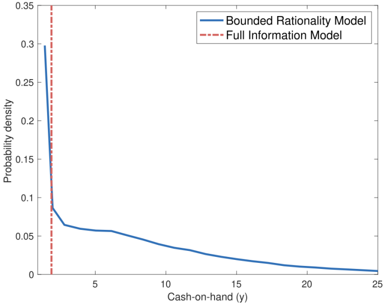
Macro implications

Stationary wealth distribution

- High fraction of agents in learning traps (71%)



(A) Asset holdings distribution (a_i)



(B) Distribution of stable wealth points $\bar{y}_i$

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