Rationally Inattentive Heterogenous Agents

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Motivation

Modeling **household heterogeneity** is important for macro,

- Transmission mechanisms.
- Amplification effects.
- Policy experiments.

Two main weaknesses when confronted to data:

- Perfect information,
  - Degenerate distribution for expectations.
  - No correlation between individual characteristics and expectations.
- High-MPC households problematic for macro persistence.

Reasearch Question

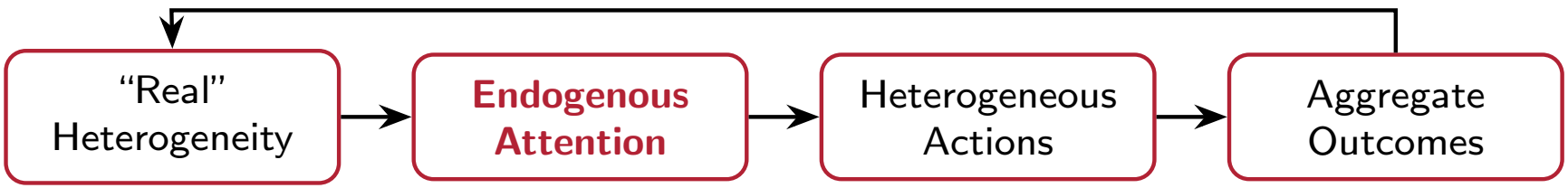
In a baseline business cycles model with heterogenous households, can **rational inattention** (RI)

- Improve the persistence of aggregate variables via slow learning? (macro moments)
- Generate cross-sectional differences in expectations accuracy consistent with survey data? (*novel* micro moments)

RI + Households Heterogeneity

Expectations accuracy and macro dynamics jointly determined in general equilibrium.

The *attention channel*:



Households Heterogeneity: A Stylized Representation

"... the effects of household heterogeneity can be largely understood by looking at the differential behavior of two types of households: hand-to-mouth ($\mathcal{H}$) and unconstrained ($\mathcal{S}$) ." Debortoli and Galí (2024)

- Expectations heterogeneity at a broad level?
- Tractable under optimal signal design.

This Paper

- In survey data, HtM's inflation forecast errors are 0.56–1.73 p.p. larger than those of other households.
- In a two-agent model, the effects of household inattention depend largely on the labor market structure,
  - Competitive wage fit micro but not macro moments. When households have labor market power the opposite occurs.
  - Policy experiments can have contrasting predictions across model variants (relevance of heterogeneity).
  - For robust predictions, insights favor labor market structures wherein unions and/or firms with monopsony power set wages.

Go to Related Literature.

Households' Measured Expectations

Data

Survey of Consumers Expectations:

- Monthly panel survey held by the NYFed.
- 1300 US households, each stays for 12M in the panel.
- Expectations about future state of the economy (fixed horizons).
- Households' characteristics (education, wage income, numeracy, etc.).
- Sample: 2013M6 to 2024M4.
- Supplemental surveys: **spending**, **credit**, finances, etc.

Identifying HtM Households

1. Negative Income Shock

Q: *Now imagine that next year you were to find yourself with 10% less household income. What would you do?*

1. **Cut spending by the whole amount**
2. Not cut spending at all, but cut my savings by the whole amount
3. Cut spending by some and cut savings by some (...)

2. Liquidity Constraint

Q: *What do you think is the % chance that you could come up with 2,000$ if an unexpected need arose within the next month?* **(treshold is set below 30%)**

3. Default Probability

Q: *What do you think is the % chance that, over the next 3 months, you will NOT be able to make one of your debt payments?* **(treshold is set above 70%)**

Some descriptive statistics.

Inflation Expectations Relative Accuracy

	Negative Income Shock	Liquidity Constraint	Default Probability
	-	-	-
Hand-to-mouth	0.563***	1.734***	1.731***
	(0.030)	(0.038)	(0.071)
High School	-	-	-
Some College	−0.732***	−0.751***	−0.862**
	(0.038)	(0.039)	(0.035)
College	−1.848***	−1.764***	−2.178***
	(0.038)	(0.040)	(0.035)
Low Numeracy	-	-	-
High Numeracy	−2.087***	−2.061***	−2.474***
	(0.033)	(0.035)	(0.030)
Unemployed	-	-	-
Part-time employed	0.041	0.107**	−0.013
	(0.048)	(0.050)	(0.044)
Full-time employed	−0.508***	−0.399***	−0.552***
	(0.033)	(0.034)	(0.030)
Observations	109,879	112,972	156,160
F Statistic	1783.44	2306.78	2981.38
R^2	0.112	0.133	0.125
Time Fixed Effects	yes	yes	yes

Notes: Estimates from regressions of the absolute value of inflation forecast errors on HtM status. Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Sample: 2013M6-2024M4.

Model

Overview: RI-DSGE

- Two variants of the baseline two-agent model,
  - RI-I: Competitive wage.
  - RI-II: Households with market power.
- RI: a tradeoff determines how agents design noisy signals about the state of the economy,
  - Information processing costs (can be thought of as time).
  - Deviations from optimal actions incur losses.
- Propagation mechanism: information frictions (learning).
- Equilibrium (fixed-point): consistency between attention allocation, individual actions, and aggregate dynamics.

Environment: Firms

- Continuum $i \in [0, 1]$ of monopolistically competitive firms.
- Production: $Y_{it} = e^{a_t} e^{a_{it}} L_{it}^{\alpha}$, with $\alpha \in (0, 1]$.
- Dividends: $D_{it} = (1 + \tau_P) P_{it} Y_{it} - W_t L_{it}$.
- Aggregate productivity: $a_t = \rho_A a_{t-1} + \varepsilon_t^A, \quad \varepsilon_t^A \sim N(0, \sigma_A^2)$.

Environment: Households

- Continuum $j \in [0,1]$ of households of two types $h \in \{\mathcal{H}, \mathcal{S}\}$.
- Preferences: $U(C_{jt}, L_{jt}) = \frac{C_{jt}^{1-\gamma}-1}{1-\gamma} - \varphi^h \frac{L_{jt}^{1+\psi}}{1+\psi}$. $\gamma > 0$, $\psi \geq 0$, $\beta \in (0,1)$.
- Composite consumption: $C_{jt} = \left(\int_0^1 C_{ijt}^{\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}}$.
- Households $j \in [0, \phi]$ are HtM ($h = \mathcal{H}$).
- For all j of type $\mathcal{H}$: $\int_0^1 P_{it} C_{ijt} di = W_{jt} L_{jt} - T^{\mathcal{H}}$.
- For all j of type $\mathcal{S}$: $\int_0^1 P_{it} C_{ijt} di + B_{jt} = W_{jt} L_{jt} + R_{t-1} B_{jt-1} + D_t^{\mathcal{S}} - T_t^{\mathcal{S}}$.

Environment: Government

- Monetary Policy,
  - Taylor Rule, $\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\Pi_t}{\Pi}\right)^{\phi_\pi} \left(\frac{Y_t}{Y_t^*}\right)^{\phi_{y^*}}\right]^{1-\rho_R} e^{\varepsilon_t^v}$.
  - $\varepsilon_t^v \sim N(0, \sigma_v^2)$.
- Fiscal Policy,
  - $T_t + B_t = R_{t-1} B_{t-1} + \tau_P \int_0^1 P_{it} Y_{it} di$.
  - Non-explosive path for real bonds.

Environment: Approximation

Discounted profits and utility, approx. with 2^{nd} order log Taylor expansions around the nsss.

- Quadratic objectives.
  (expected losses from suboptimal actions are of second-order)
- Linear laws of motion for the state and optimality conditions.

$\Rightarrow$ Given Gaussian signals, optimal actions are determined via Kalman filtering.

Attention Problems

$$\max_{\boldsymbol{\Gamma},\boldsymbol{\Sigma}_\nu} \left\{ \sum_{t=0}^{\infty} \beta^t E_{-1} \left[\frac{1}{2} (\boldsymbol{x}_t - \boldsymbol{x}_t^*)' \boldsymbol{\Theta} (\boldsymbol{x}_t - \boldsymbol{x}_t^*) \right] - \lambda \sum_{t=0}^{\infty} \beta^t I(\boldsymbol{\xi}_t; \boldsymbol{S}_{it} | \mathcal{I}_{it-1}) \right\} \quad (1)$$

subject to

$$\boldsymbol{\xi}_{t+1} = \boldsymbol{F}\boldsymbol{\xi}_t + \boldsymbol{\mu}_{t+1} \ , \ \boldsymbol{\mu_{t+1}} \sim N(\boldsymbol{0}, \boldsymbol{\Sigma}_\mu) \quad (2)$$

$$\boldsymbol{x}_t^* = \boldsymbol{G}\boldsymbol{\xi}_t \quad (3)$$

$$\mathcal{I}_{it} = \mathcal{I}_{i,-1} \cup \{\boldsymbol{S}_{i0}, ..., \boldsymbol{S}_{it}\} \quad (4)$$

$$\boldsymbol{S_{it}} = \boldsymbol{\Gamma}\boldsymbol{\xi}_t + \boldsymbol{\nu_{it}} \ , \ \boldsymbol{\nu_{it}} \sim N(\boldsymbol{0}, \boldsymbol{\Sigma}_\nu) \quad (5)$$

$$I(\boldsymbol{\xi}_t; \boldsymbol{S_{it}} | \mathcal{I}_{it-1}) = H(\boldsymbol{\xi}_t | \mathcal{I}_{it-1}) - H(\boldsymbol{\xi}_t | \mathcal{I}_{it}). \quad (6)$$

$$\boldsymbol{x}_t = E[\boldsymbol{x}_t^* | \mathcal{I}_{it}]. \quad (7)$$

Equilibrium

In periods $t = 0, 1, 2, ...$

- Households maximize given their information set.
- Firms maximize given their information set.
- Markets clear.
- Agent's perceived law of motion of the economy are consistent with the actual law of motion (rational expectations).

In period -1,

- Prior uncertainty, $\Sigma_{0|-1}$, is at the s.s. value implied by $\{\Gamma^*, \Sigma_\nu^*\}$ $\forall i, j$.

Numerical solution method

Losses from Suboptimal Actions

Firms set a price for their variety p_{it}.

* $\mathbf{\Theta}_i = -(C^{\mathcal{S}})^{-\gamma} Y \left[\frac{\tilde{\theta}(\tilde{\theta}+\alpha(1-\tilde{\theta}))}{\alpha}\right]$

RI-I: Competitive Labor Market

Every household supply labor l_{jt}, $\mathcal{S}$ choose consumption c_{jt}.

* $\mathbf{\Theta}_j^{\mathcal{H}} = -(C^{\mathcal{H}})^{1-\gamma} \left[\frac{C^{\mathcal{H}}}{WL}\left(\frac{C^{\mathcal{H}}}{WL}\gamma + \psi\right)\right]$

* $\mathbf{\Theta}_j^{\mathcal{S}} = -(C^{\mathcal{S}})^{1-\gamma} \begin{bmatrix} \gamma & 0 \\ 0 & \frac{C^{\mathcal{S}}}{WL}\psi \end{bmatrix}$

RI-II: Households with Market Power

Every household set a wage w_{jt}, $\mathcal{S}$ choose consumption c_{jt}.

* $\mathbf{\Theta}_j^{\mathcal{H}} = -(C^{\mathcal{H}})^{1-\gamma} \left[\tilde{\eta}\frac{C^{\mathcal{H}}}{WL}\left(1 + \tilde{\eta}\left(\gamma\frac{C^{\mathcal{H}}}{WL} + \psi\right)\right)\right]$

* $\mathbf{\Theta}_j^{\mathcal{S}} = -(C^{\mathcal{S}})^{1-\gamma} \begin{bmatrix} \gamma & 0 \\ 0 & \tilde{\eta}\frac{C^{\mathcal{S}}}{WL}(1+\tilde{\eta}\psi) \end{bmatrix}$

Estimation

Strategy

Period: 1969Q1-2019Q4.

- **Calibration**
  - Structural parameters: business cycles litterature and financial survey data (*Survey of Consumers Finances*).
  - Exogenous shocks: model-consistent estimates from the data.

- **Estimation**
  - Marginal costs of attention: "moment matching".
    - λ_i: serial correlation of inflation.
    - λ_j: serial correlation of output growth. (**homogenous across households**)

More details on heterogeneity parameters.

Parameters

Panel A: Calibrated Parameters

Parameter		Value
β	Discount factor	0.99
γ	EIS	1.5
ψ	Inverse Frisch	1.0
α	Labor share	0.66
$\tilde{\theta}$	Price elasticity of demand	4.0
$\tilde{\eta}$	Wage elasticity of demand	4.0
ϕ	HtM share	0.28
$\frac{C^S}{C^{\mathcal{H}}}$	Steady-state consumption ratio	1.4
ρ_r	Taylor rule inertia	0.9
ϕ_π	Taylor rule coefficient (inflation)	1.5
ϕ_{y^*}	Taylor rule coefficient (output gap)	0.125
ρ_a	Persistence of aggregate technology	0.95
$100\sigma_a$	100× S.D. of aggregate technology shocks	0.8
$100\sigma_v$	100× S.D. of monetary policy shock	0.2

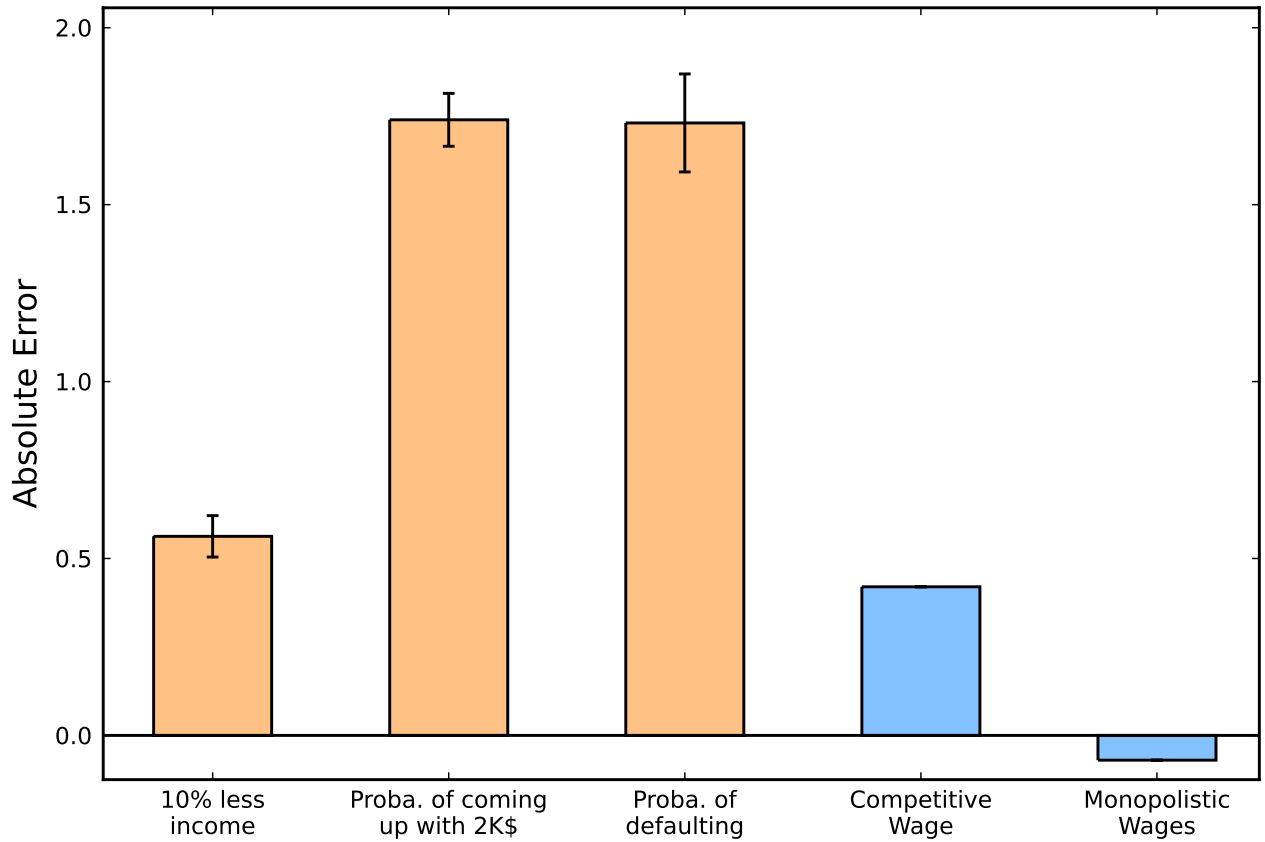
Panel B: Inattention Parameters

Parameter		Value
RI-I: competitive-wage		
λ_j	Firms marginal cost of attention	485.0
λ_j	Households marginal cost of attention	0.8
RI-II: monopolistic-wage		
λ_j	Firms marginal cost of attention	33.0
λ_j	Households marginal cost of attention	5.8
RI-F: inattentive firms, attentive households		
λ_j	Firms marginal cost of attention	360.0

Numerical values for losses from suboptimal actions.

Results

Inflation Expectations Relative Accuracy

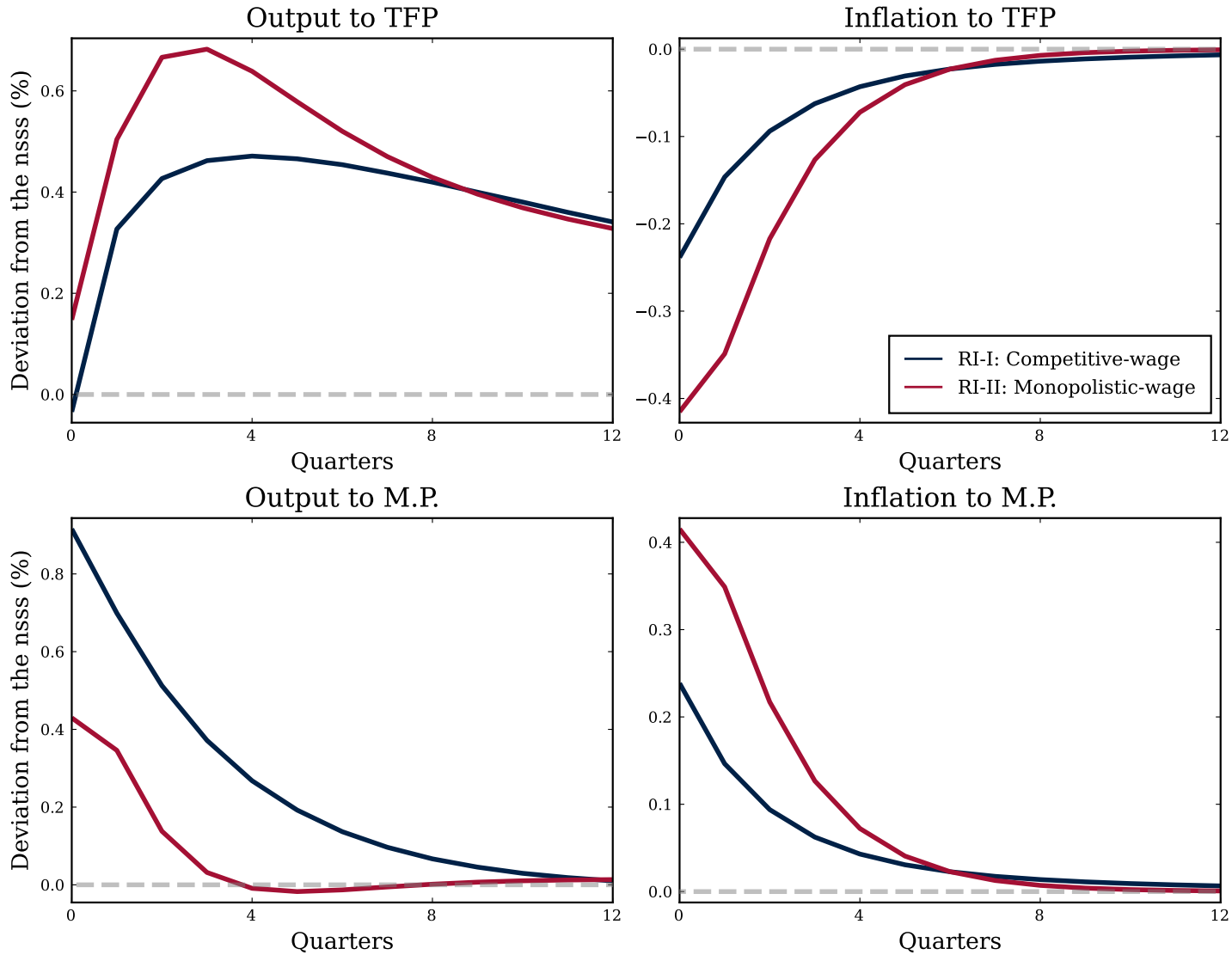


Unconditional Moments

	Data	RI-I	RI-II	RI-F	PI
Targeted Moments					
ρ_{π}	0.62	0.62	0.62	0.62	0.023
$\rho_{\Delta y}$	**0.3**	**-0.06**	**0.3**	-0.14	-0.025
Untargeted Moments					
$\rho_{\Delta w}$	0.48	-0.20	0.63	-0.18	-0.025
$\sigma_{\pi}/\sigma_{\Delta y}$	1.06	0.33	1.15	0.37	1.17
$\sigma_{\Delta w}/\sigma_{\Delta y}$	1.10	3.72	0.80	3.07	2.81
$\beta_{\pi,\mathcal{H}}$	1.73	0.42	-0.07	-	-

Notes: RI-I: competitive-wage. RI-II: monoplistic-wage. RI-F: only firms s.t. RI. PI: both firms and hhs with perfect info.

Conditional Moments

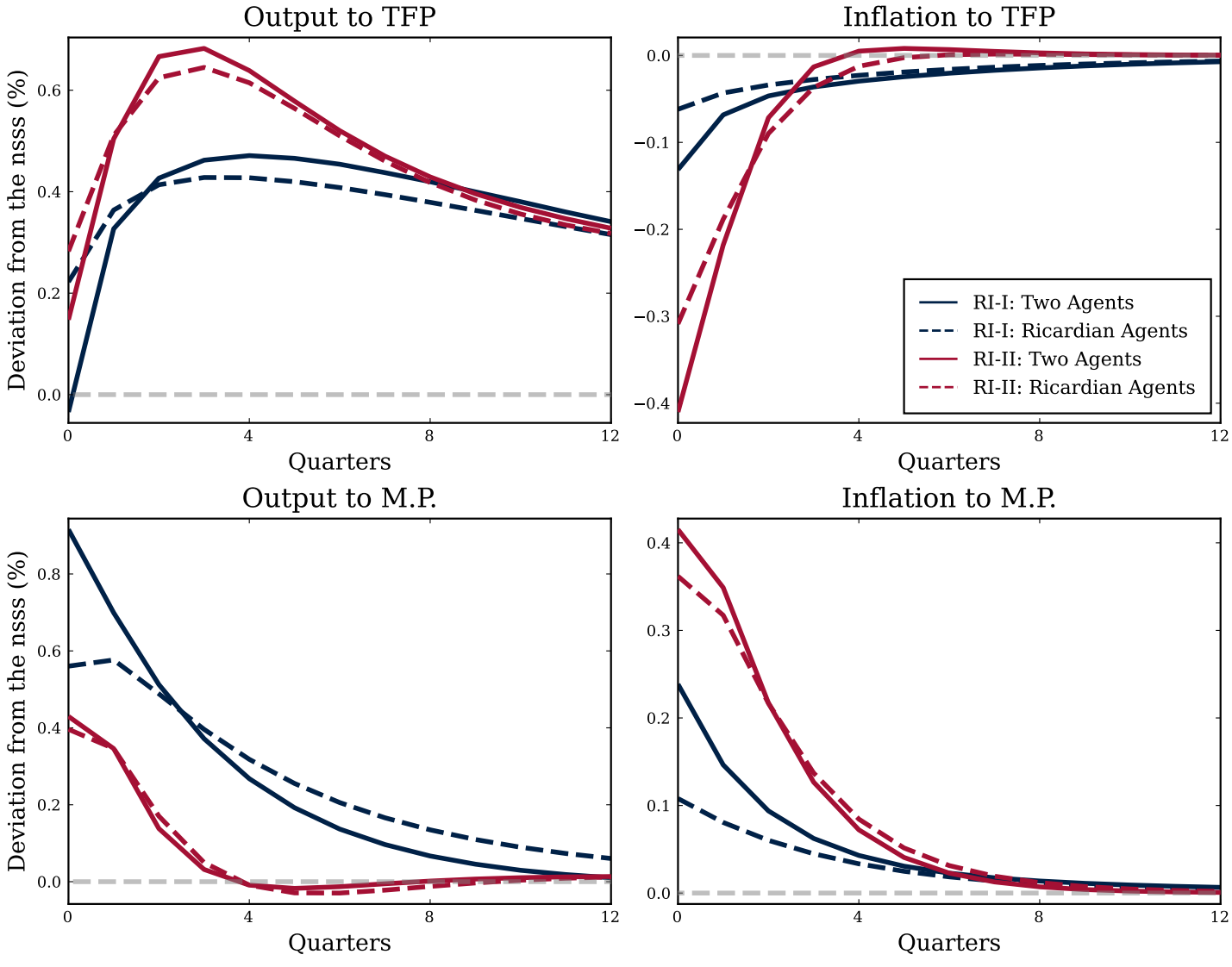


Relevance of Heterogeneity

		RI-I		RI-II	
	Data	TA	RA	TA	RA
ρ_{π}	0.62	0.62	0.75	0.62	0.69
$\rho_{\Delta y}$	**0.3**	**-0.06**	**0.19**	**0.3**	**0.34**
$\rho_{\Delta w}$	0.48	-0.20	-0.12	0.63	0.59
$\sigma_{\pi}/\sigma_{\Delta y}$	1.06	0.33	0.29	1.15	1.10
$\sigma_{\Delta w}/\sigma_{\Delta y}$	1.10	3.72	4.05	0.80	0.85

Notes: TA for two-agent models. RA for Ricardian models.

Relevance of Heterogeneity



Takeaways

Neither variant can match both micro *and* macro moments.

- **Competitive wage**
  - Labor income (and HtM consumption) peaked on impact.
  - Consumption-saving lead to more accurate forecasts for $\mathcal{S}$.
- **Households with market power**
  - Labor income (and HtM consumption) hump shaped.
  - Attention largely driven by the wage-setting (labor supply) decision.

Ways Out of the Conundrum

For robust predictions, can we match micro *and* macro moments?

Two Criteria

- Incentives to avoid labor supply mistakes must be of similar magnitude as those for consumption–saving.
- Dynamic response of wages (and labor income) must be hump-shaped.

Compatible microfoundations

- Wages set by unions.
- Market power on the side of firms (monopsony).

Conclusion

Conclusion

Previous work: RI with Ricardian households,

- Implies realistic degree of aggregate information rigidity.
- Induce inertial response to shocks.

This paper: RI with heterogenous households,

- Does not necessarily induce persistence in macro variables *and* cross-sectional expectations accuracy that match the data.
- Model variants have different conclusions regarding the relevance of heterogeneity.
- Can (should) serve to discipline the model's microfoundations.

Related Literature

- HA models with endogenous attention,
  - Expectation and Wealth Heterogeneity in the Macroeconomy, Mitman et al. (2022).
  - Firm inattention and the efficacy of monetary policy: A text-based approach, Song and Stern (2020).
- RI-DSGE,
  - Maćkowiak and Wiederholt (2015, 2023),
  - Afrouzi and Yang (2021).
- Two-agent models,
  - Bilbiie (2008, 2020),
  - Debortoli and Galí (2024).

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Descriptive Statistics

	Negative Income Shock	Liquidity Constraint	Default Probability
ϕ (HtM share)	0.47	0.24	0.04
Median liquid assets			
Hand-to-mouth	3,450$	-4,500$	-20,000$
Savers	10,500$	15,000$	8,000$
Inflation forecast errors			
Median ratio	0.83	0.57	0.65
S.D. ratio	0.88	0.74	0.79
Interest rate forecast errors			
Median ratio	0.95	0.85	0.97
S.D. ratio	0.98	0.97	1.03

Notes: Liquid assets as the current value of savings accounts (excluding retirement accounts) minus outstanding debt (excluding housing). Forecast errors measured in absolute values. Ratios savers over HtM.

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Equilibrium: Numerial Procedure

Guess and Verify

0. Guess stoch. processes for the aggregate laws of motion.
1. Obtain a low order VARMA representation for the attention problems' state vectors.
2. Solve the attention problems.
3. Aggregate individual actions.
4. Compare the resulting laws of motions with their initial guesses.
5. Update guesses, and repeat until convergence.

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Calibration of Heterogeneity Parameters

Estimating the Share of HtM

- Compute net liquid wealth.
- Obtain credit limit.
- Using Kaplan, Violante, and Weidner (2014)'s estimator identify households at their credit limit or with 0 net liquid wealth.

Estimating the Consumption Ratio

- Compute total gross income.
- Apply the tax rate.
- Compute savings required to maintain constant net liquid wealth at some inflation rate.
- Infer consumption from the difference between after-tax income and savings.
- Take the median across both types.

ϕ and $\frac{C^{\mathcal{S}}}{C^{\mathcal{H}}}$ are set to their average over the SCF sample.

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Losses from Suboptimal Actions

RI-I: Competitive Labor Market

* $\mathbf{\Theta}_j^{\mathcal{H}} = -1.14 \left[1.94\right]$
* $\mathbf{\Theta}_j^{\mathcal{S}} = -0.96 \begin{bmatrix} 1.5 & 0 \\ 0 & 0.61 \end{bmatrix}$

RI-II: Households with Market Power

* $\mathbf{\Theta}_j^{\mathcal{H}} = -1.14 \left[34.44\right]$
* $\mathbf{\Theta}_j^{\mathcal{S}} = -0.96 \begin{bmatrix} 1.5 & 0 \\ 0 & 12.14 \end{bmatrix}$

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