
Spend What You (L)earn

Adrien Auclert	Stanford
Hugo Monnery	Harvard
Matt Rognlie	Northwestern
Ludwig Straub	Harvard

NBER Summer Institute, Monetary Economics, July 2026

Income expectations and aggregate demand

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- ❖ **Here:** “HANK” model with **learning about income**

- ❖ agents can’t fully tell idiosyncratic from aggregate income

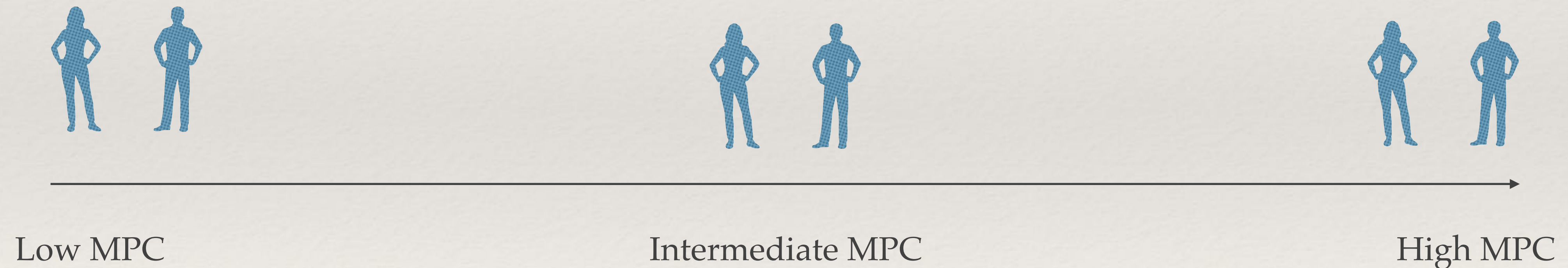
[as in Lucas 1972]

- ❖ learn from own income to form $\mathbb{E}[\text{future income}]$

- ❖ solve with new **general methodology** on how to embed learning in sequence space

- ❖ In **HA** vs {**RA**, **TA**}, **learning multiplier**: income expectations $\leftrightarrow$ aggregate demand

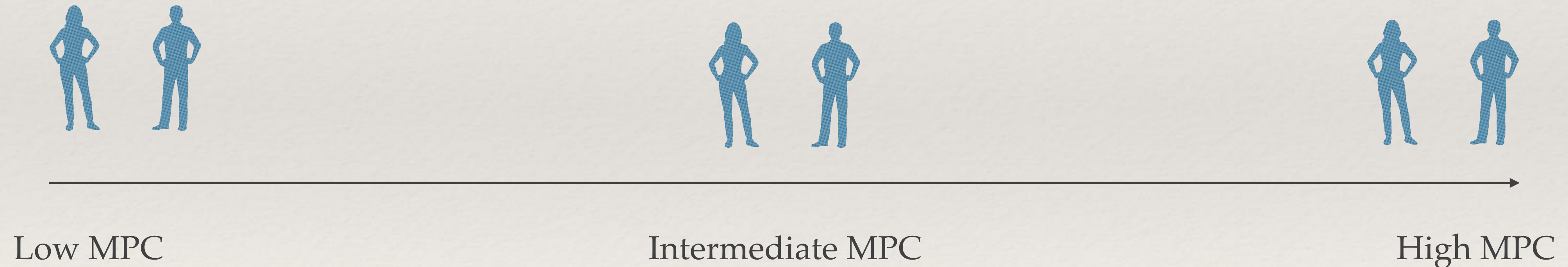
Why learning and heterogeneity go together



MPC or proximity to borrowing constraint

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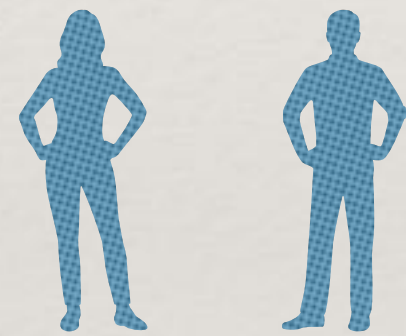
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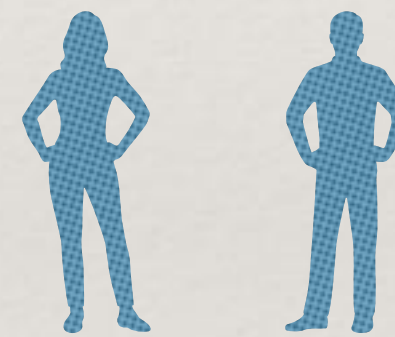
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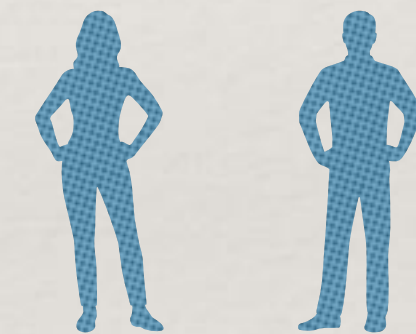


Low MPC

Beliefs about future income don't matter because households are constrained!



Intermediate MPC

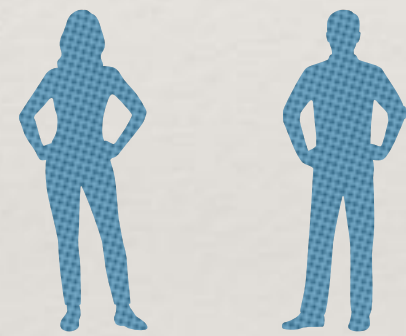


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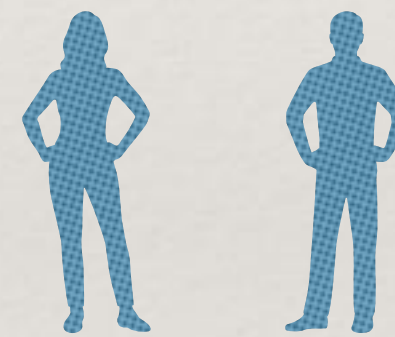
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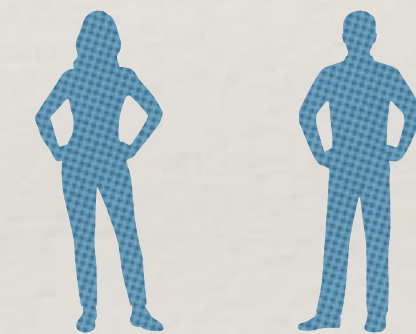
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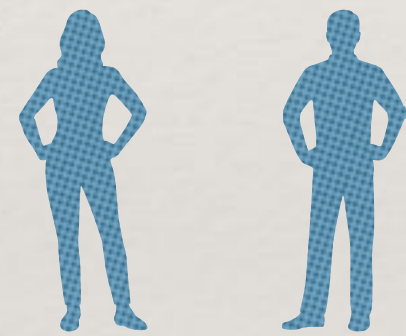


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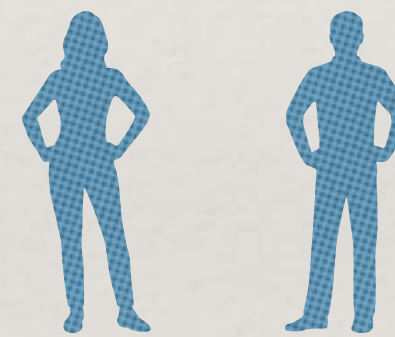
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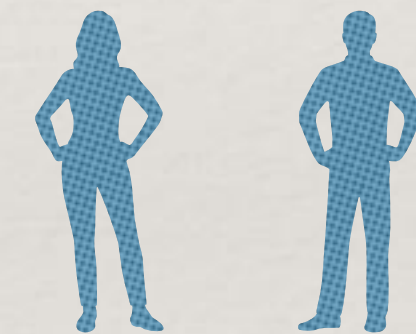
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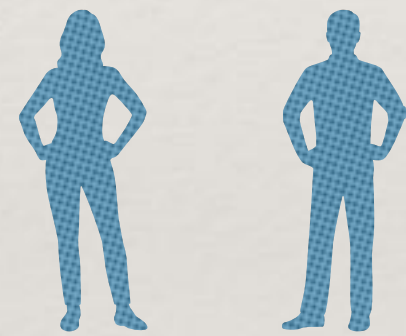
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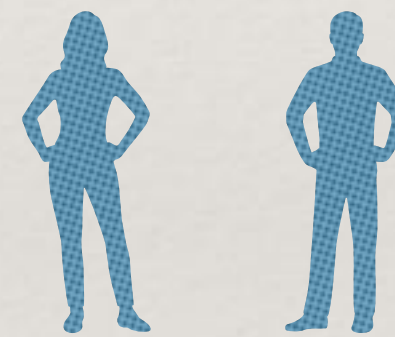
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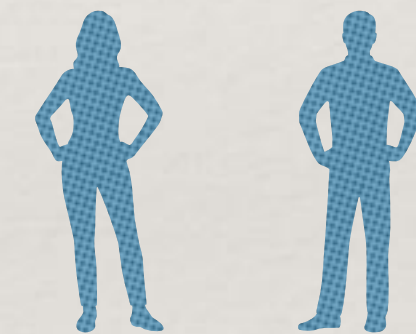
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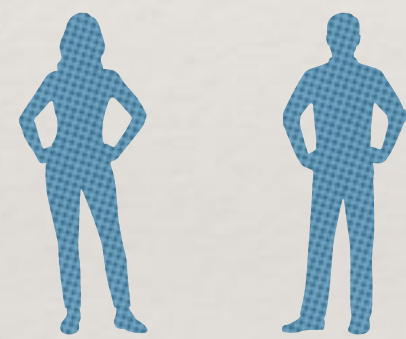


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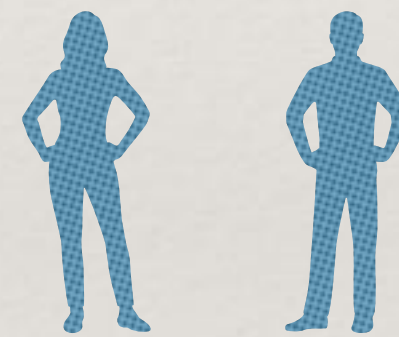
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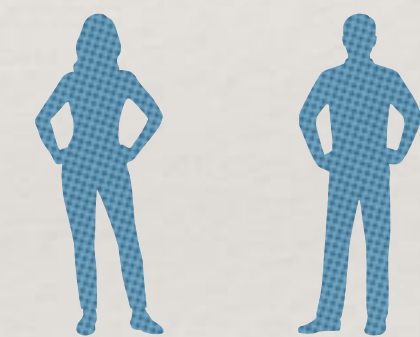
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Literature

- ❖ Sentiment and dispersed info in business cycles: Lucas; Lorenzoni; Nimark; Angeletos–La’O; Angeletos–Collard–Dellas; Angeletos–Huo; Angeletos–Huo–Sastry; Bordalo–Gennaioli–Ma–Shleifer
- ❖ Micro evidence on expectations and spending: Manski; Coibion–Gorodnichenko; Weber–D’Acunto–Coibion–Gorodnichenko; Malmendier–Nagel; Armantier–Topa–van der Klaauw–Zafar; Roth–Wohlfart; Andre–Haaland–Pizzinelli–Wiederholt–Wohlfart; Bachmann–Elstner–Sims; Kuchler–Piazzesi–Stroebe; Colarieti–Mei–Stantcheva
- ❖ Macro models with non-FIRE expectations and heterogeneous agents: Mankiw–Reis–Wolfers; Carroll; Maćkowiak–Wiederholt; Eusepi–Preston; Ilut–Schneider; Ilut–Schneider–Luetticke; Kohlhas–Walther; Broer–Kohlhas–Mitman–Schlafmann; Farhi–Werning; Auclert–Rognlie–Straub; Pfäuti–Seyrich; Guerreiro; Bardóczy–Guerreiro; Adams–Rojas; Overhage

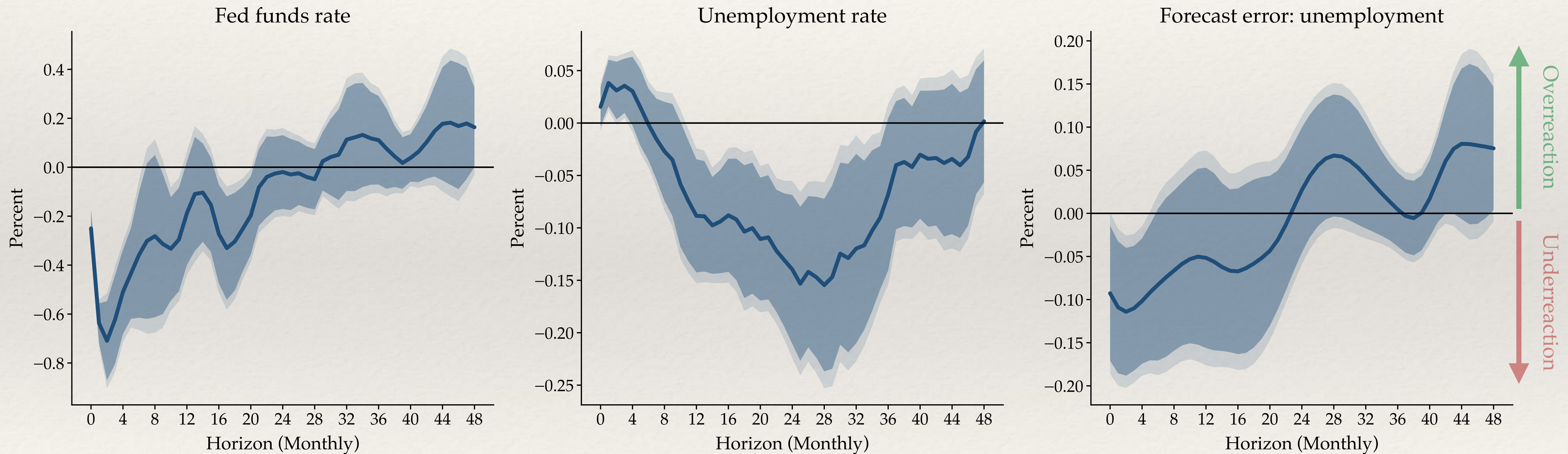
Roadmap

1. Motivating facts
2. PE: Heterogeneous agents with learning
3. GE: “HANK” model with learning
4. Learning multiplier

Motivating facts

Fact 1: Delayed overreaction

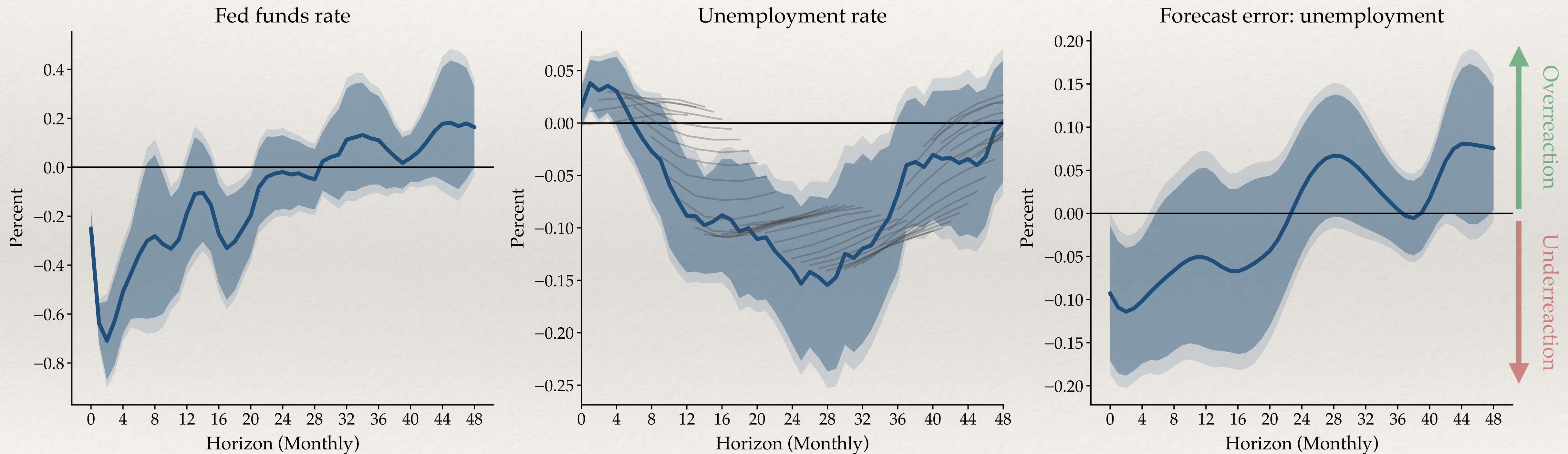
Original Romer-Romer shock, with SPF forecasts [Angeletos Huo Sastry (2023)]



90% & 95% confidence bands

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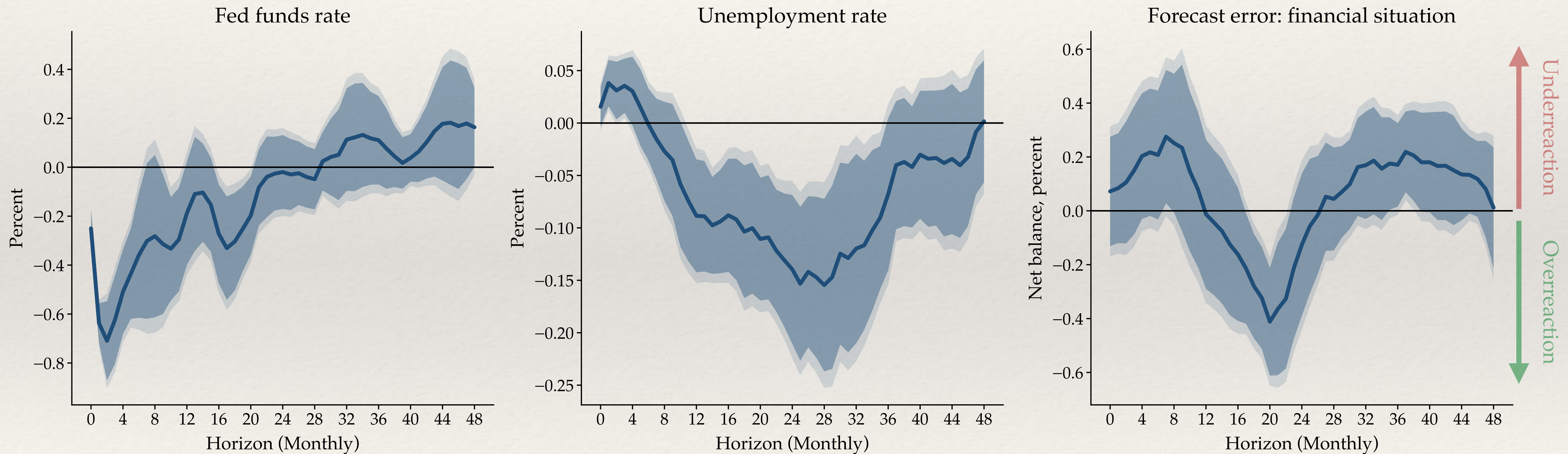
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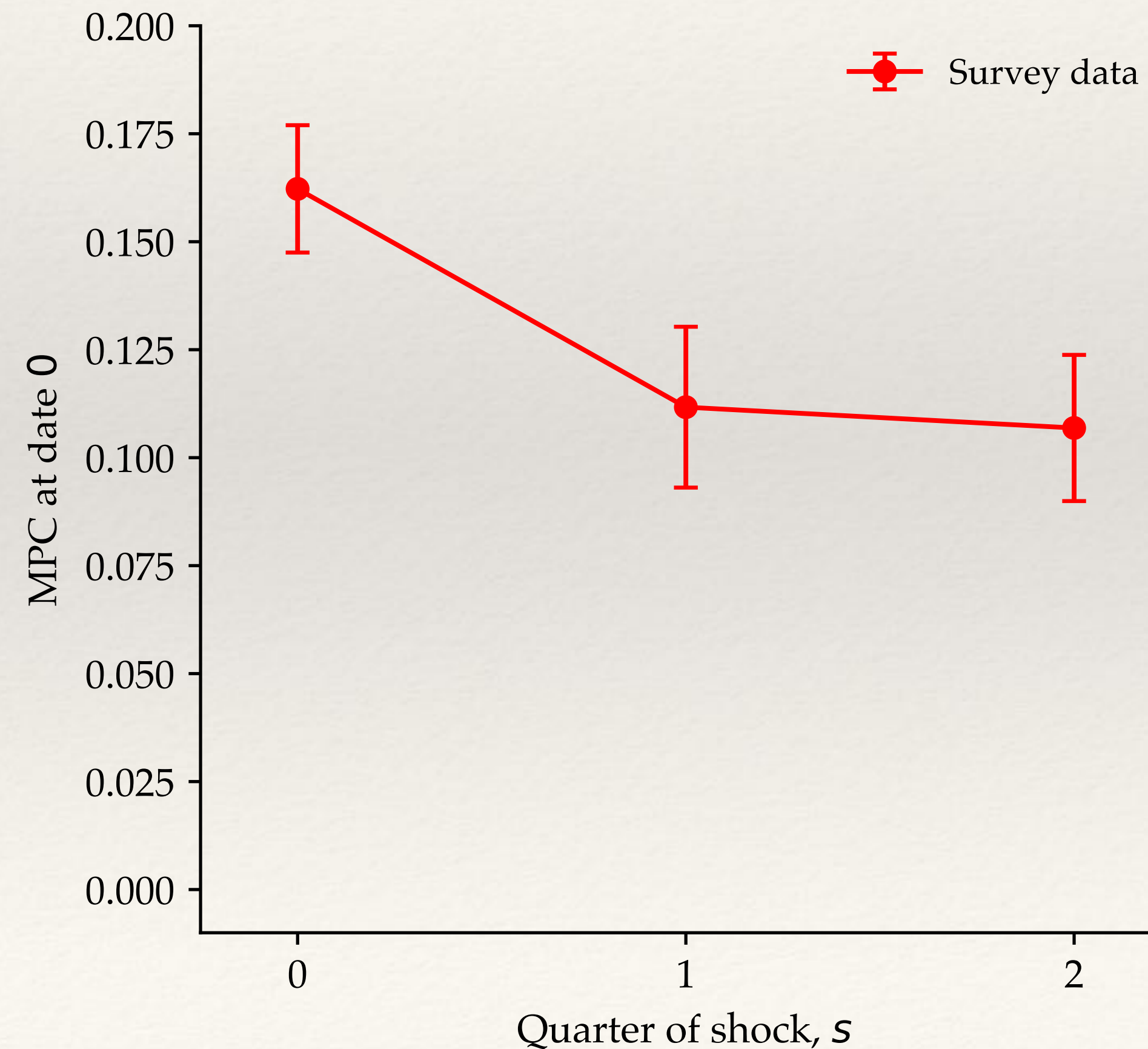
Original Romer-Romer shock, with Michigan survey forecast errors



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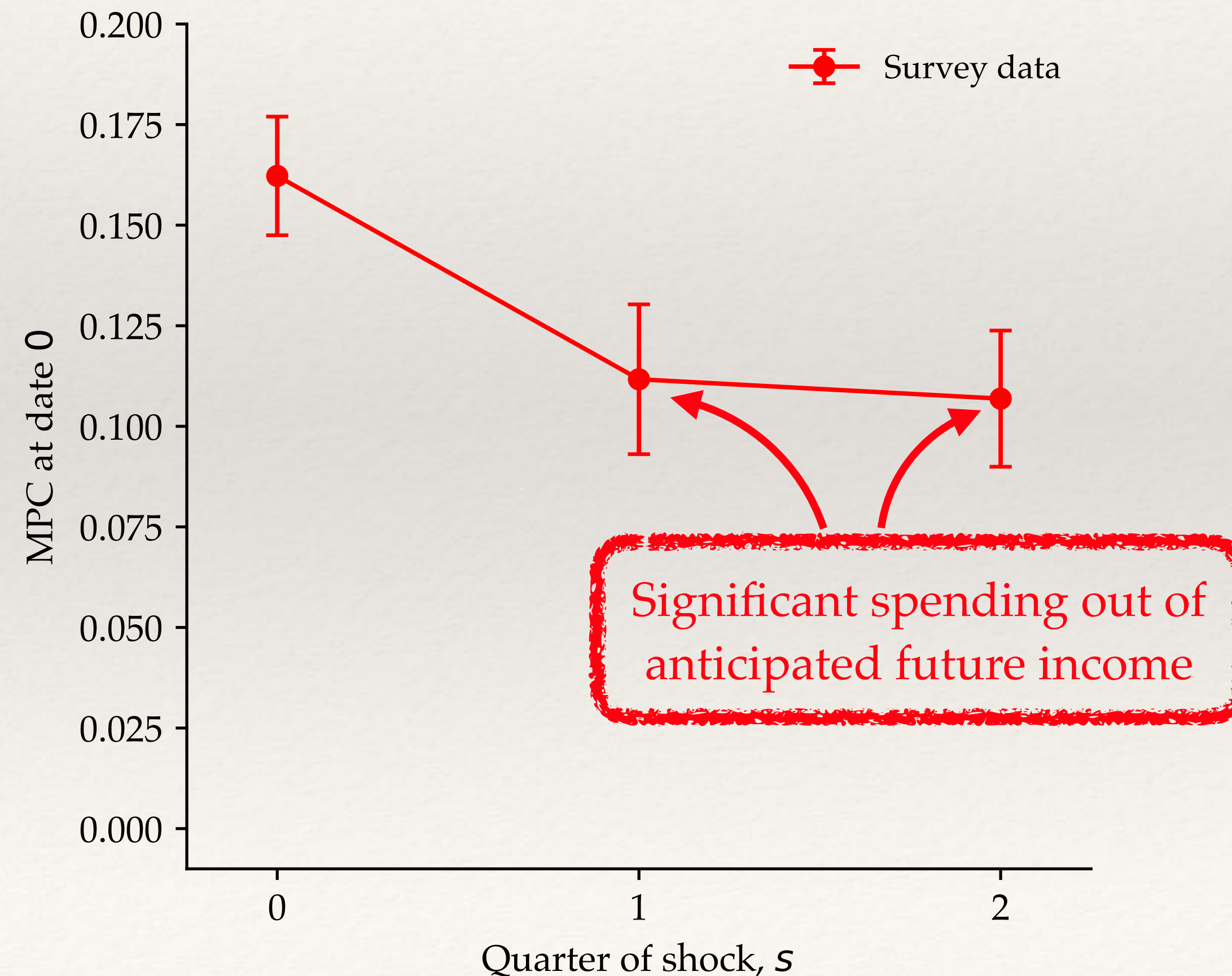
Fact 2: Income expectations and spending

Responses of spending to anticipated income shocks (Colarieti, Mei, Stantcheva, 2025)



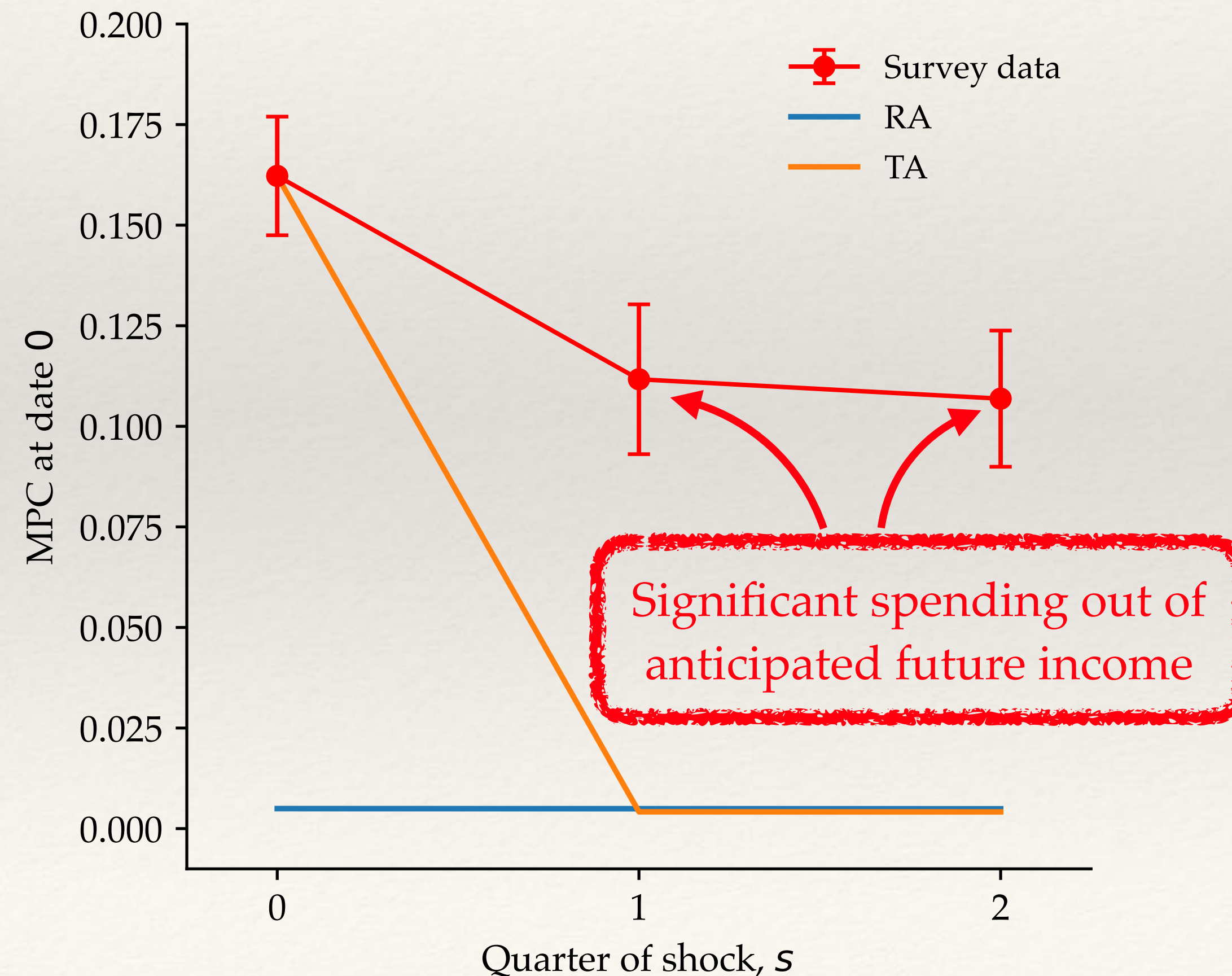
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Heterogeneous agents with learning

Heterogeneous households in the sequence space

- ❖ Consider standard heterogeneous household problem under “FIRE”

$$\max \mathbb{E}_{i\tau} \left[\sum_{t=\tau}^{\infty} \beta^{t-\tau} u(c_{it}) \right] \quad c_{it} + a_{it} = (1 + r) a_{it-1} + y_{it} \quad a_{it} \geq 0$$

For now: Full
information rational
expectations (FIRE)

$$y_{it} = e_{it} Y_t$$

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- ❖ Result (IKC): to first order in std. dev. of ϵ_t aggregate consumption follows:

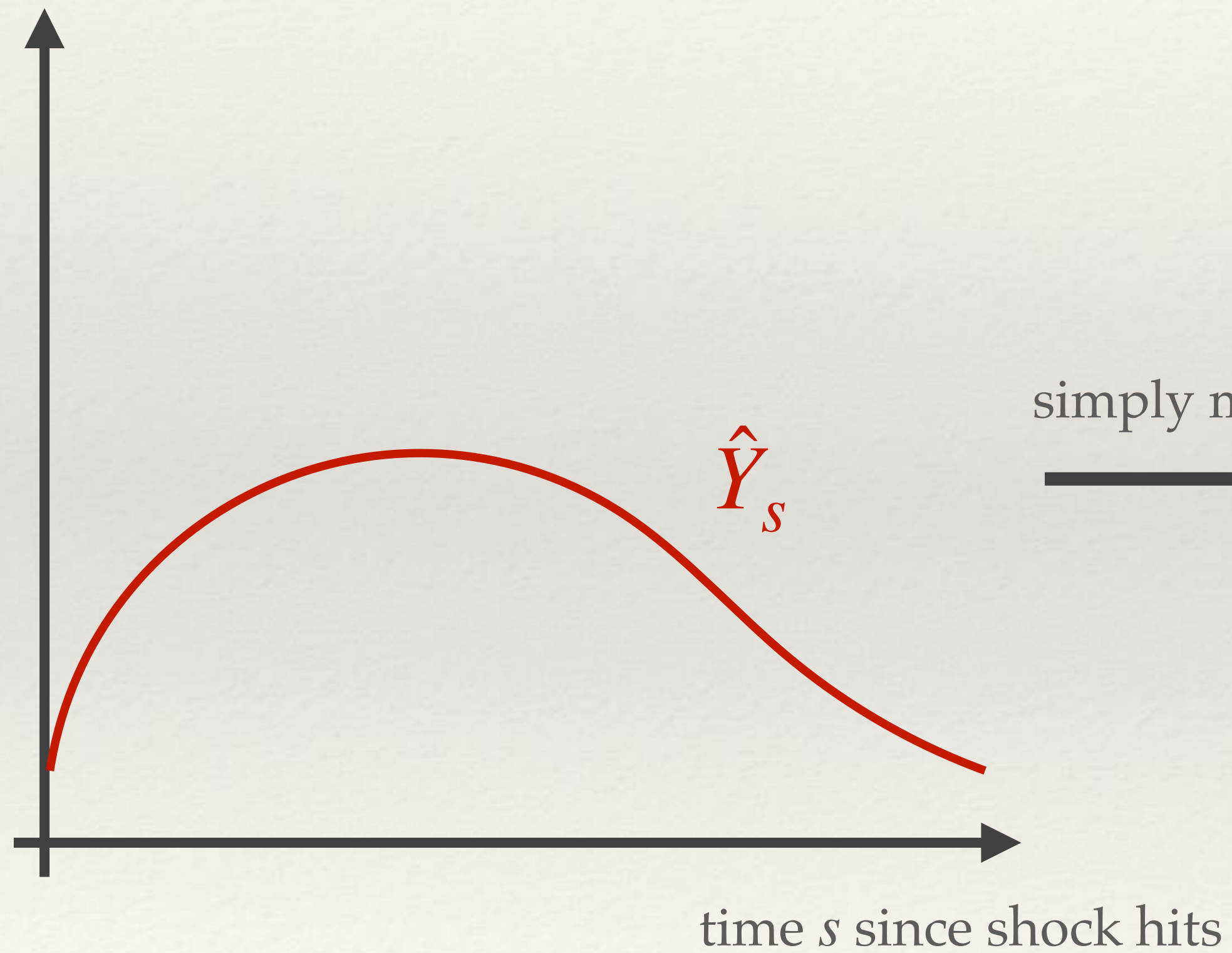
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$$\hat{C} = \mathbf{M} \cdot \hat{\mathbf{Y}}$$

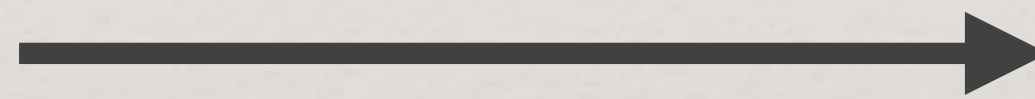
intertemporal MPC matrix

In terms of impulse responses

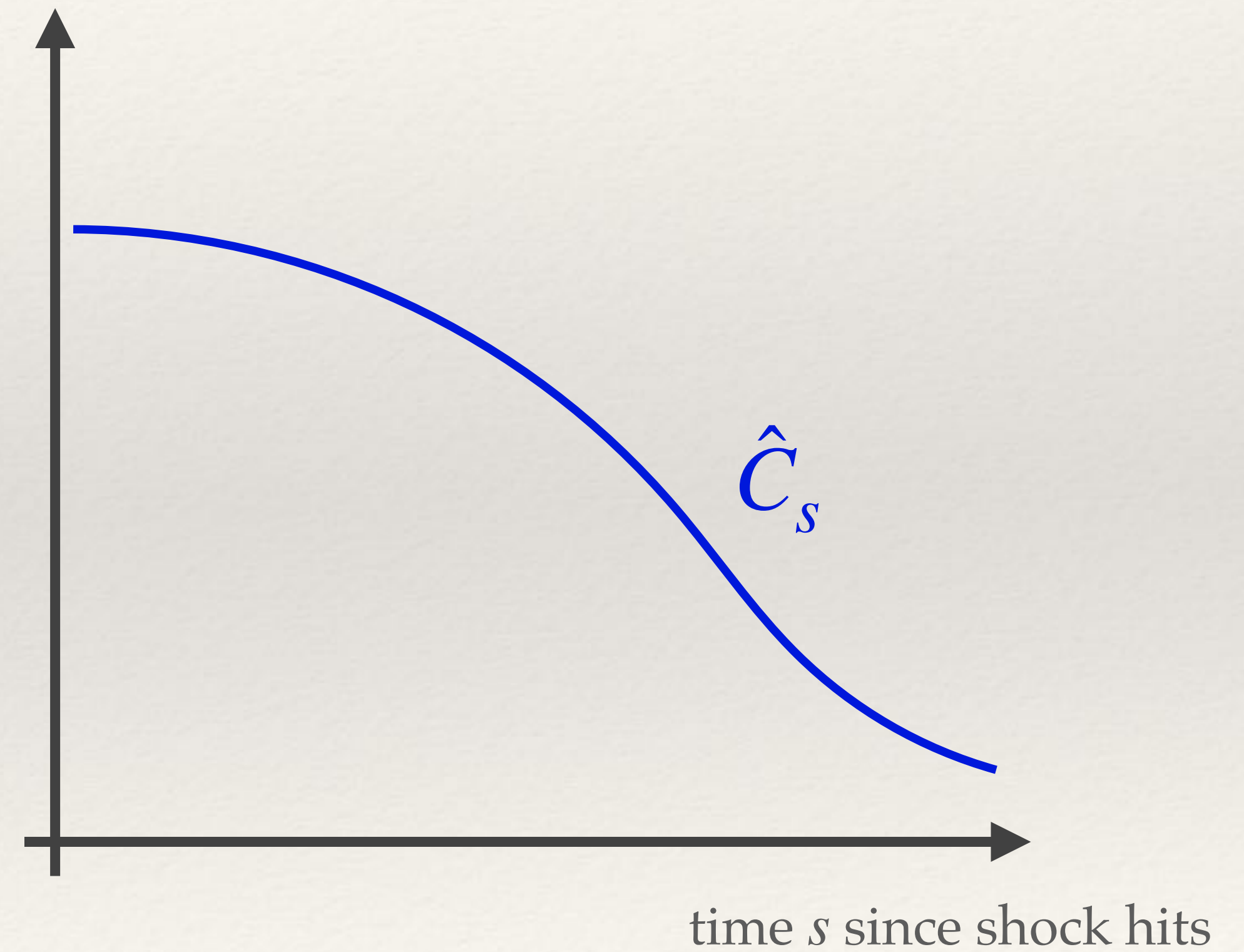
IRF of Y



simply multiply IRF with $\mathbf{M}$



IRF of C



Intertemporal MPCs

$$\mathbf{M} = \begin{pmatrix} M_{00} & M_{01} & M_{02} & M_{03} & \cdots \\ M_{10} & M_{11} & M_{12} & M_{13} & \cdots \\ M_{20} & M_{21} & M_{22} & M_{23} & \cdots \\ M_{30} & M_{31} & M_{32} & M_{33} & \cdots \\ \vdots & \vdots & \vdots & \vdots & \ddots \end{pmatrix}$$

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Key Q: How will agents form income expectations?

Income expectations

❖ Key object: average income expectations. What are they?

❖ FIRE:

$$d \int \mathbb{E}_{it}[y_{it+h}] di = \mathbb{E}_t[dY_{t+h}] = \sum_{s=0}^{\infty} \hat{Y}_{s+h} \epsilon_{t-s}$$

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❖ Next: Postulate matrix $F_{s,h}$ which describes average income expectations

$$d \int \mathbb{E}_{it}[y_{it+h}] di = \sum_{s=0}^{\infty} F_{s,h} dY_{t-s}$$

Term structure of expectations

Lags of realized aggregate income

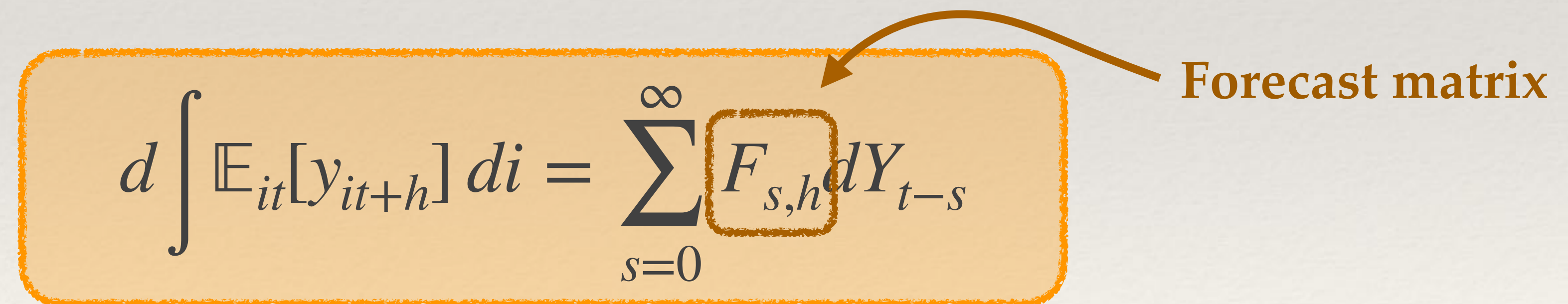
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Forecast matrix

Term structure of expectations

Lags of realized aggregate income

What admits a forecast matrix representation?

- ❖ Bayesian learning (with or without drifting parameters) [Eusepi-Giannoni-Preston, Farmer-Nakamura-Steinsson]
- ❖ Least-squares learning (with or without constant gain) [Eusepi-Preston, Marcet-Sargent, Evans-Honkapohja]
- ❖ Dispersed information, $y_{it} = e_{it}^{(obs)} e_{it}^{(unobs)} Y_t$ [Angeletos-Huo, Morris-Shin]
- ❖ Dispersed information with diagnostic expectations [Bordalo-Gennaioli-Ma-Shleifer]
- ❖ Extrapolation, natural expectations [Laibson-Fuster-Mendel]
- ❖ Structural reinforcement learning [Yang-Wang-Schaab-Moll]

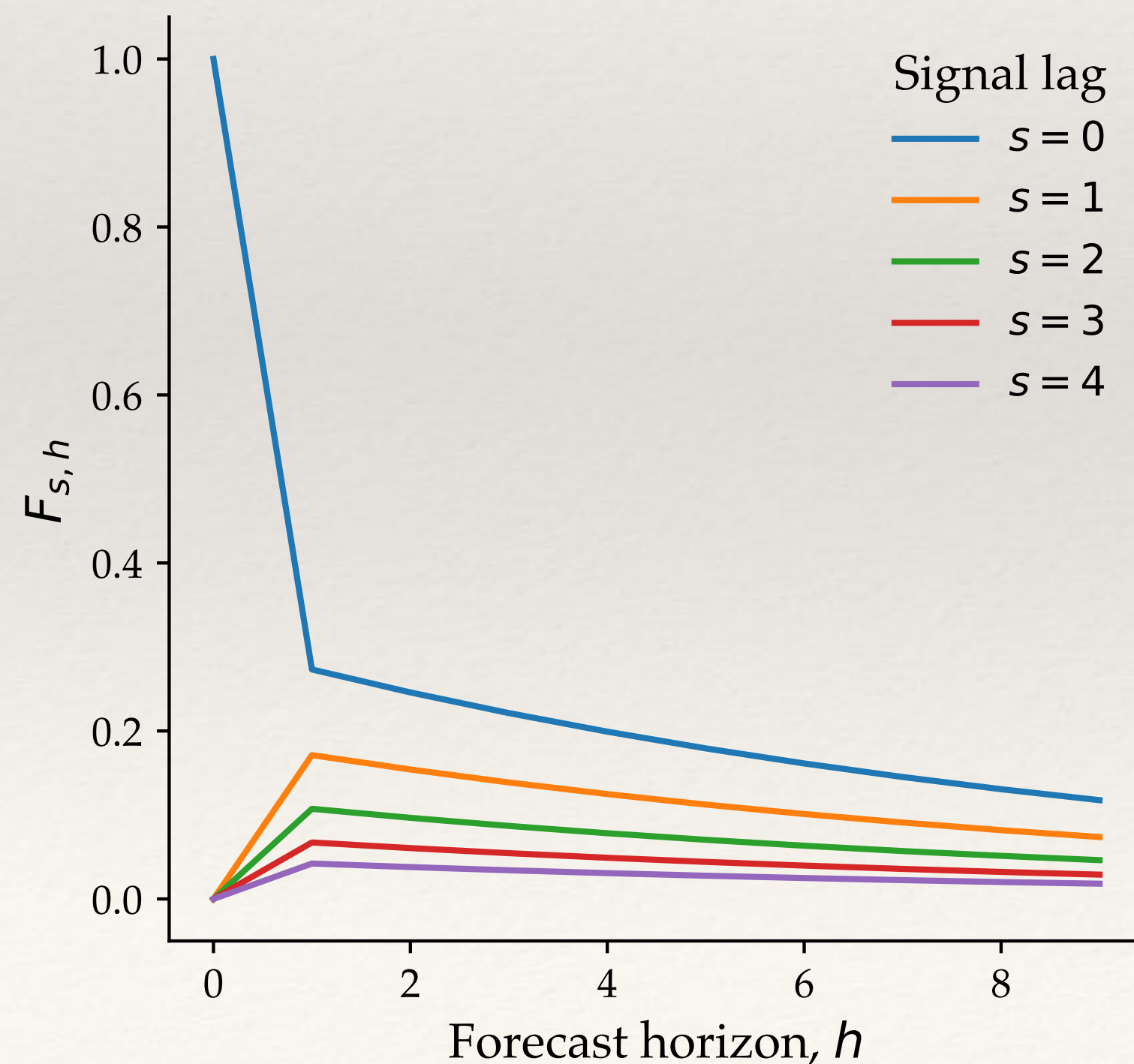
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Example: Forecast matrix with dispersed info

Assume $e_{it}^{(unobs)}$ is AR(1) + iid
and households ignore Y_t

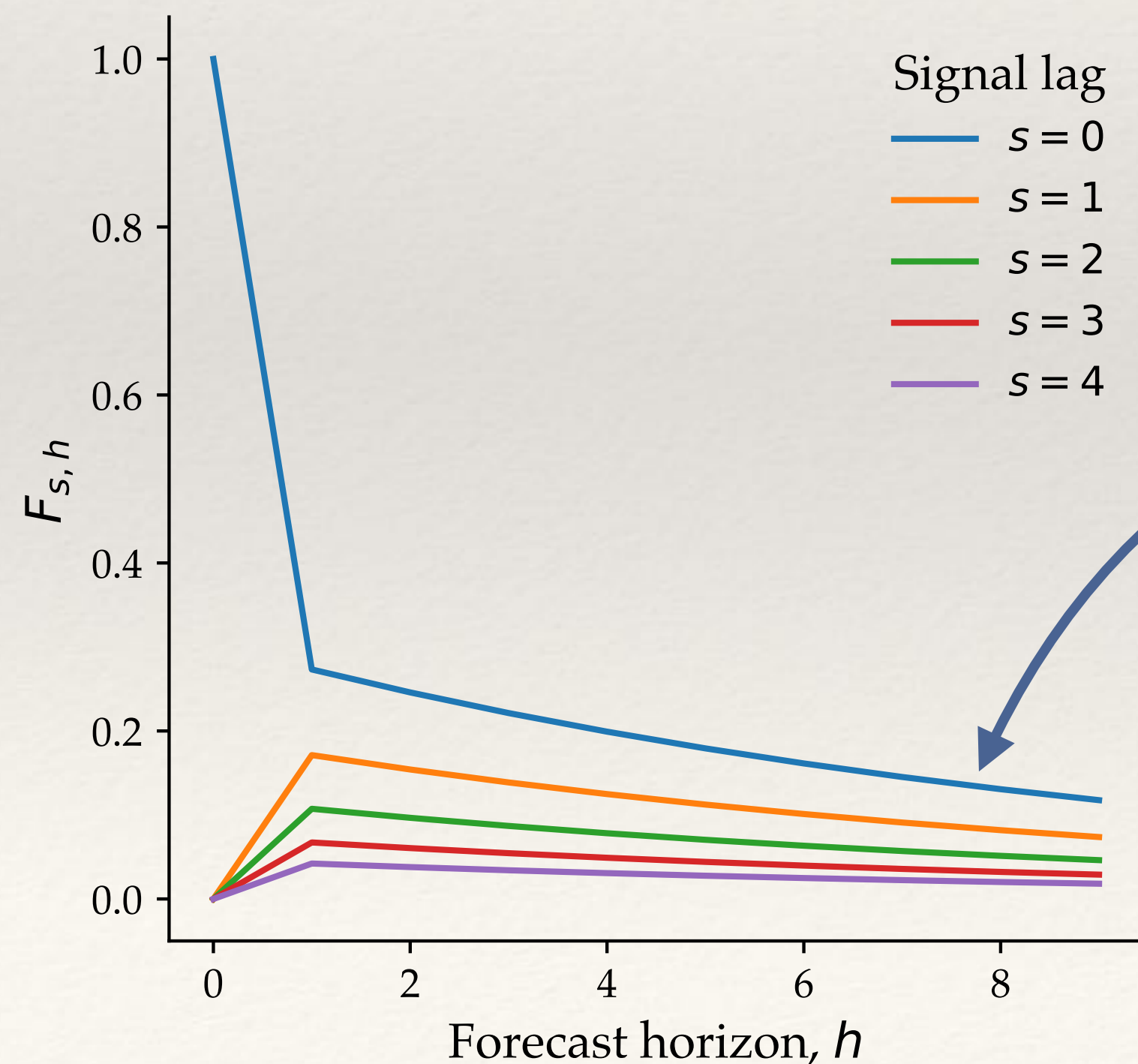
$$\mathbf{F} = \begin{pmatrix} 1 & \rho K & \rho^2 K & \rho^3 K & \dots \\ 0 & \rho K \rho (1 - K) & \rho^2 K \rho (1 - K) & \rho^3 K \rho (1 - K) & \dots \\ 0 & \rho K (\rho (1 - K))^2 & \rho^2 K (\rho (1 - K))^2 & \rho^3 K (\rho (1 - K))^2 & \dots \\ 0 & \rho K (\rho (1 - K))^3 & \rho^2 K (\rho (1 - K))^3 & \rho^3 K (\rho (1 - K))^3 & \dots \\ \vdots & \vdots & \vdots & \vdots & \ddots \end{pmatrix}$$



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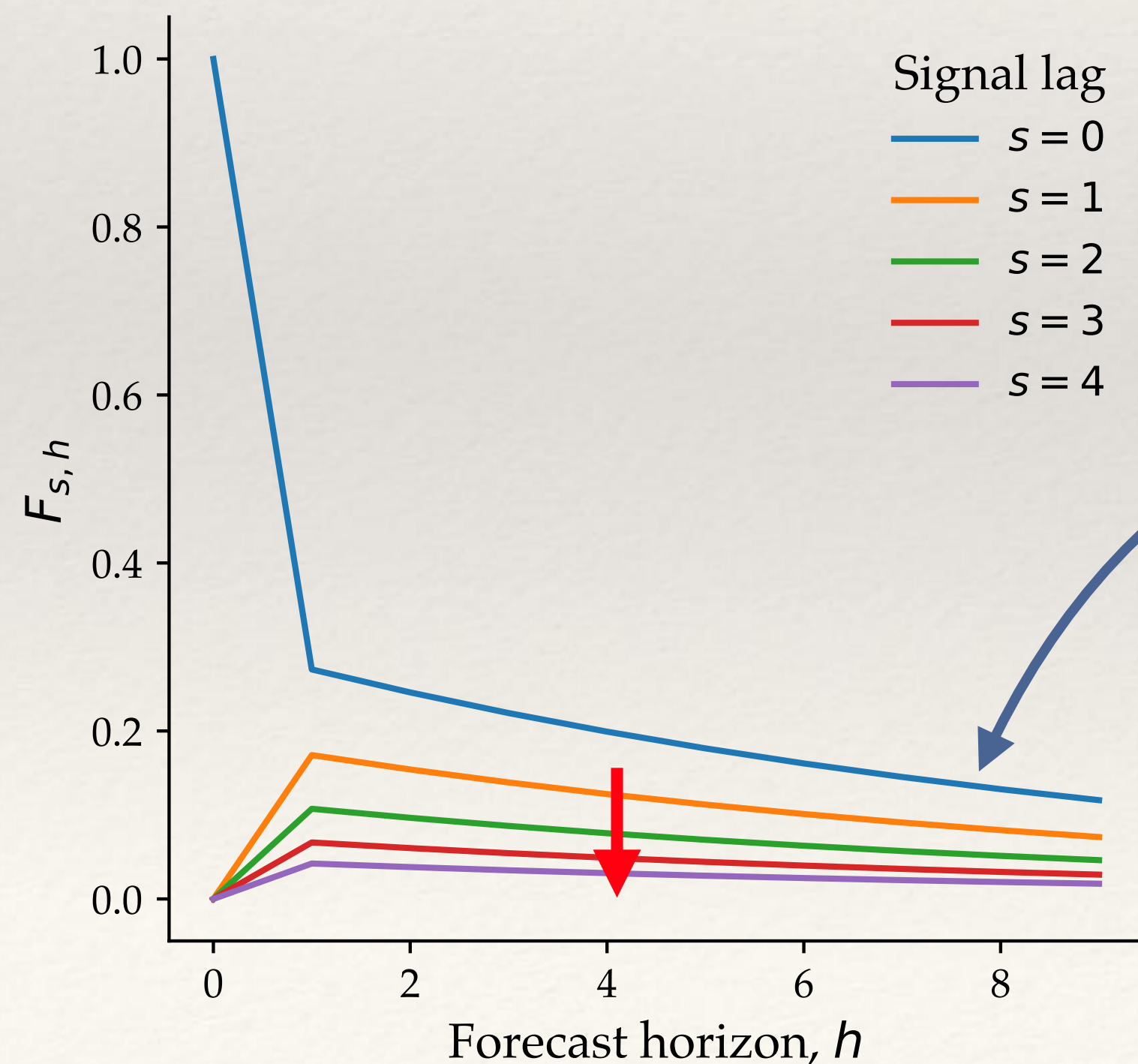


First become optimistic
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First become optimistic
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... then expectations slowly
decline back to zero.

Main theory result: Jacobians with learning

- ❖ Forecast matrix helps describe consumption response

iMPCs out of future income

Initial forecast

$$\tilde{C}_0 = \sum_{h=0}^{\infty} \boxed{M_{0,h}} \times \boxed{F_{0,h} \hat{Y}_0}$$

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iMPCs out of future income Initial forecast

$$\tilde{C}_0 = \sum_{h=0}^{\infty} \boxed{M_{0,h}} \times \boxed{F_{0,h} \hat{Y}_0}$$

$$\tilde{C}_1 = \sum_{h=0}^{\infty} \boxed{M_{1,h}} \times \boxed{F_{0,h} \hat{Y}_0}$$

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iMPCs out of future income

Initial forecast

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Forecast revision

$$\tilde{C}_1 = \sum_{h=0}^{\infty} \boxed{M_{1,h}} \times \boxed{F_{0,h} \hat{Y}_0} + \sum_{h=0}^{\infty} \boxed{M_{0,h}} \times \boxed{F_{1,h} \hat{Y}_0 + F_{0,h} \hat{Y}_1 - F_{0,h+1} \hat{Y}_0}$$

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Result: With learning and forecast matrix $\mathbf{F}$, consumption responds as

$$\hat{\mathbf{C}} = \tilde{\mathbf{M}} \cdot \hat{\mathbf{Y}}$$

where $\tilde{\mathbf{M}}$ is lower triangular with each column like

$$\tilde{M}_{t,0} = \sum_{s=0}^t \sum_{h=0}^{\infty} M_{t-s,h} (F_{s,h} - F_{s-1,h+1})$$

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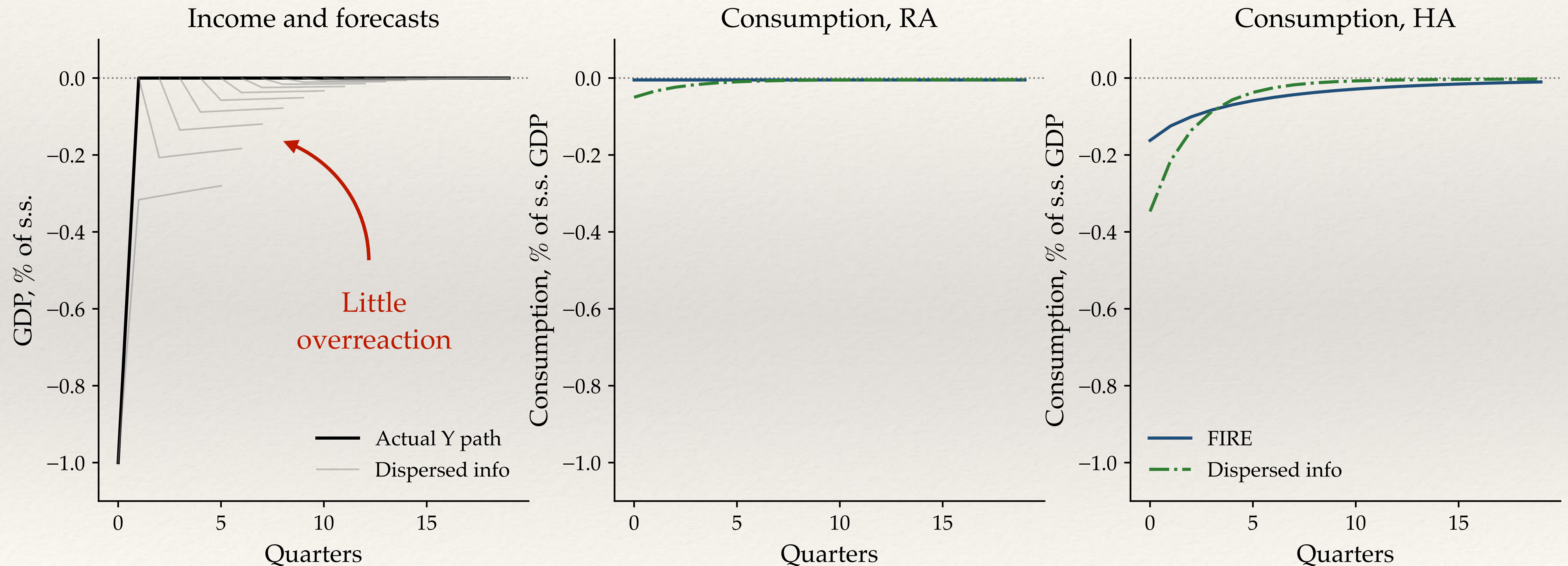
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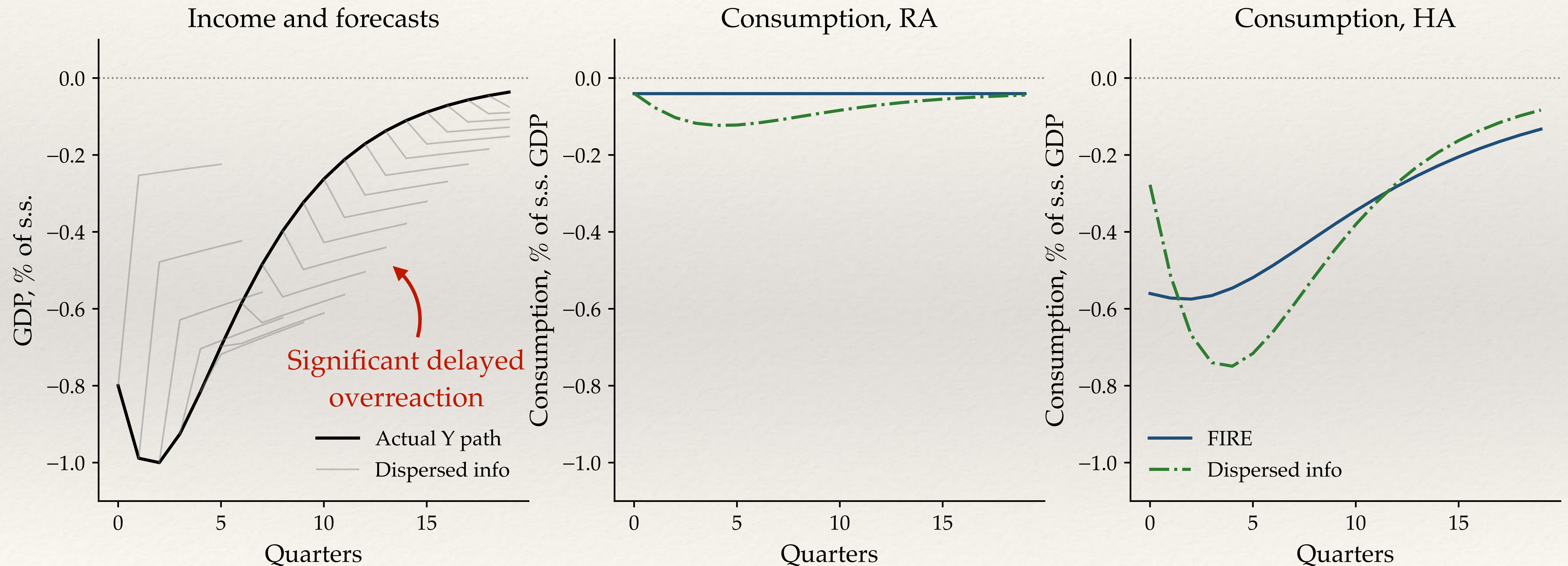
$$\tilde{M}_{t,0} = \sum_{s=0}^t \sum_{h=0}^{\infty} M_{t-s,h} (F_{s,h} - F_{s-1,h+1})$$

This makes it straightforward to solve HA models with learning!

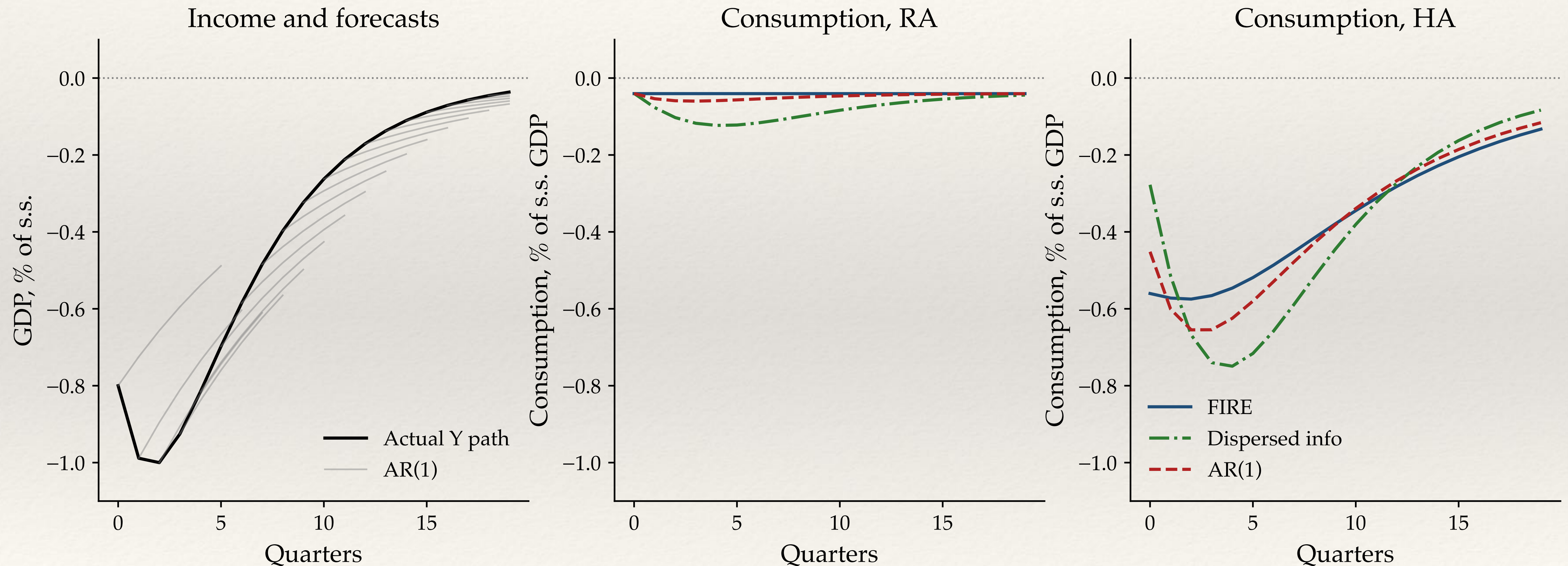
Delayed overreaction in partial equilibrium



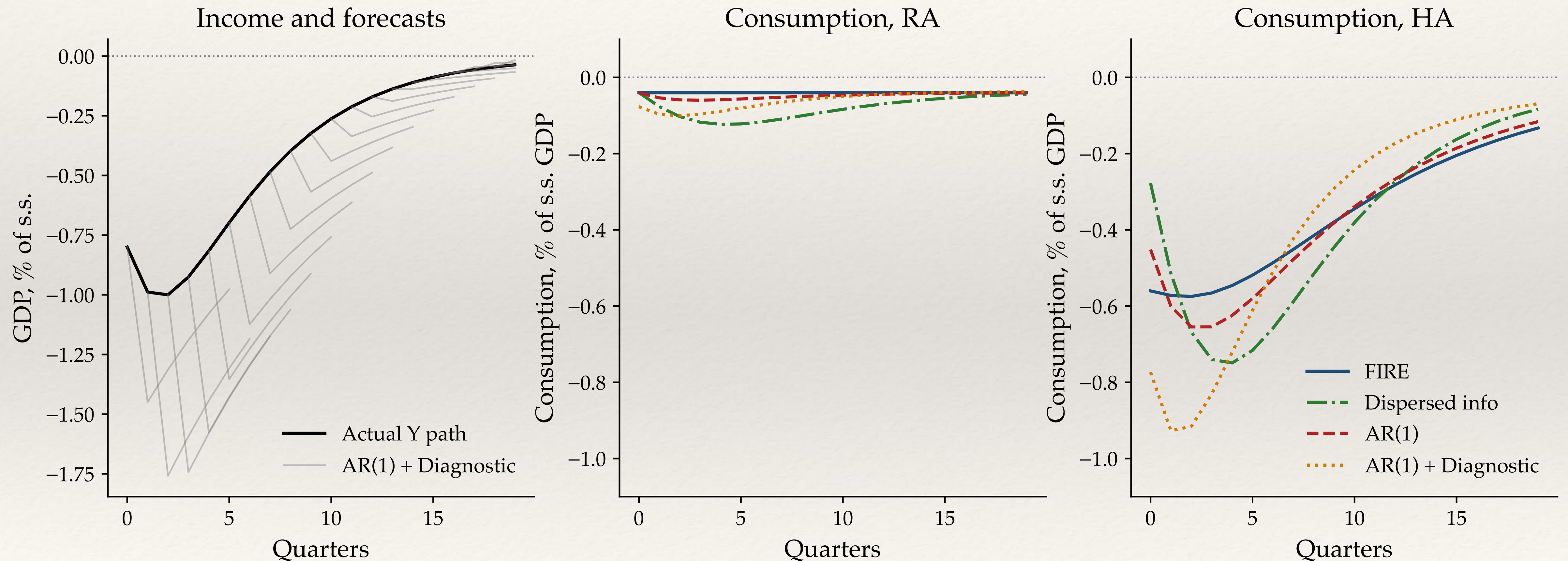
Delayed overreaction in partial equilibrium



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Delayed overreaction in partial equilibrium

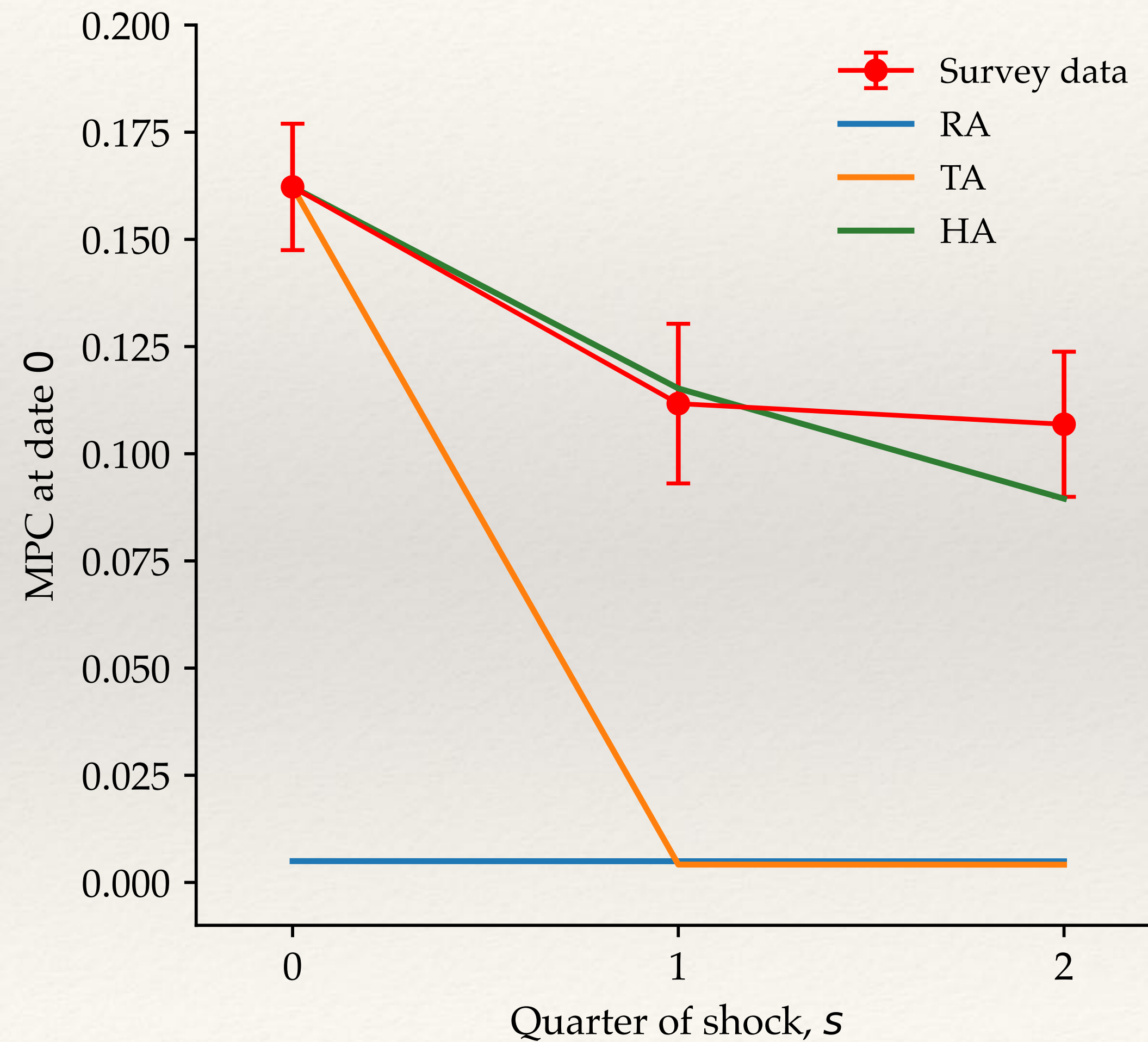


HANK model with learning

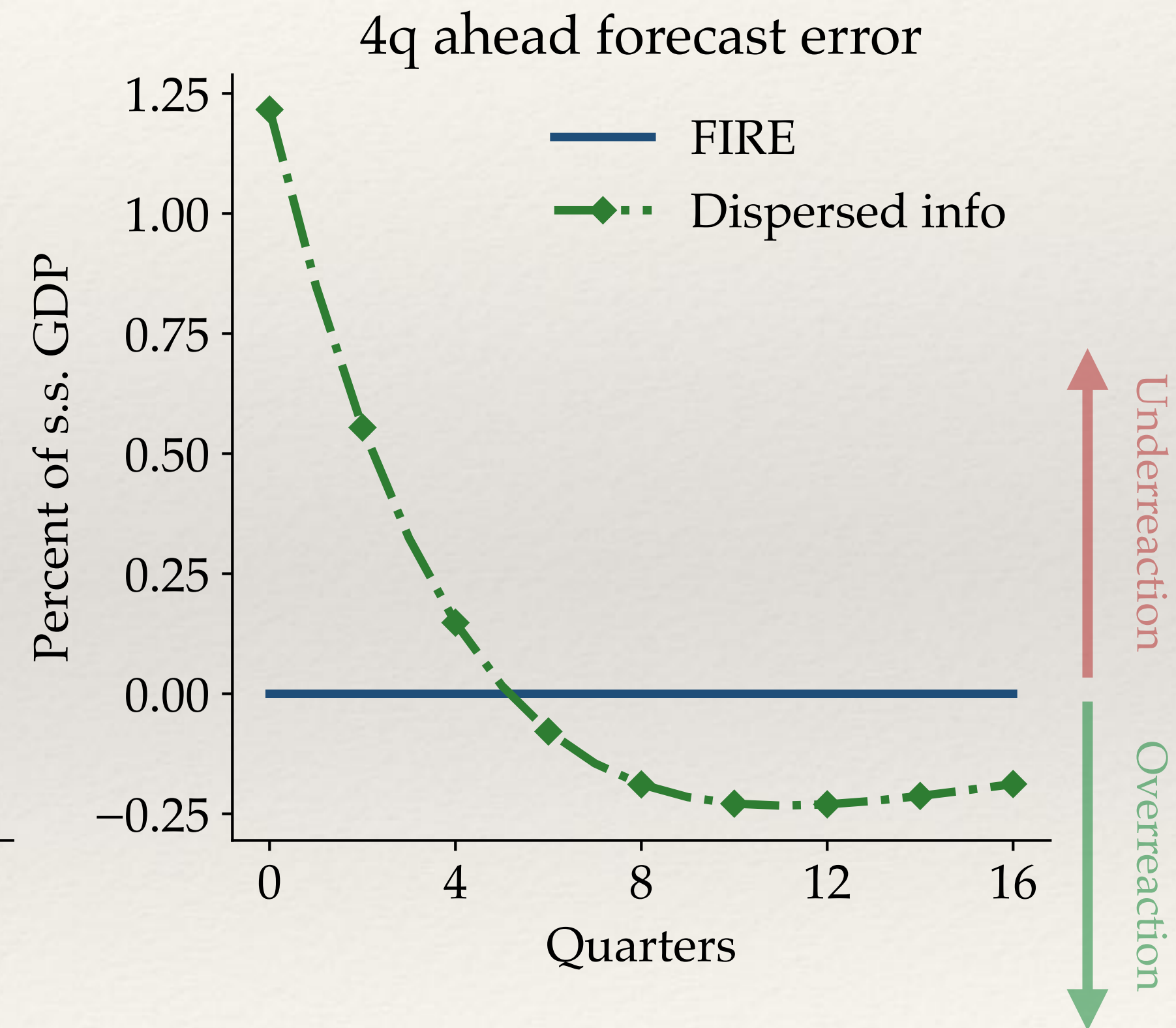
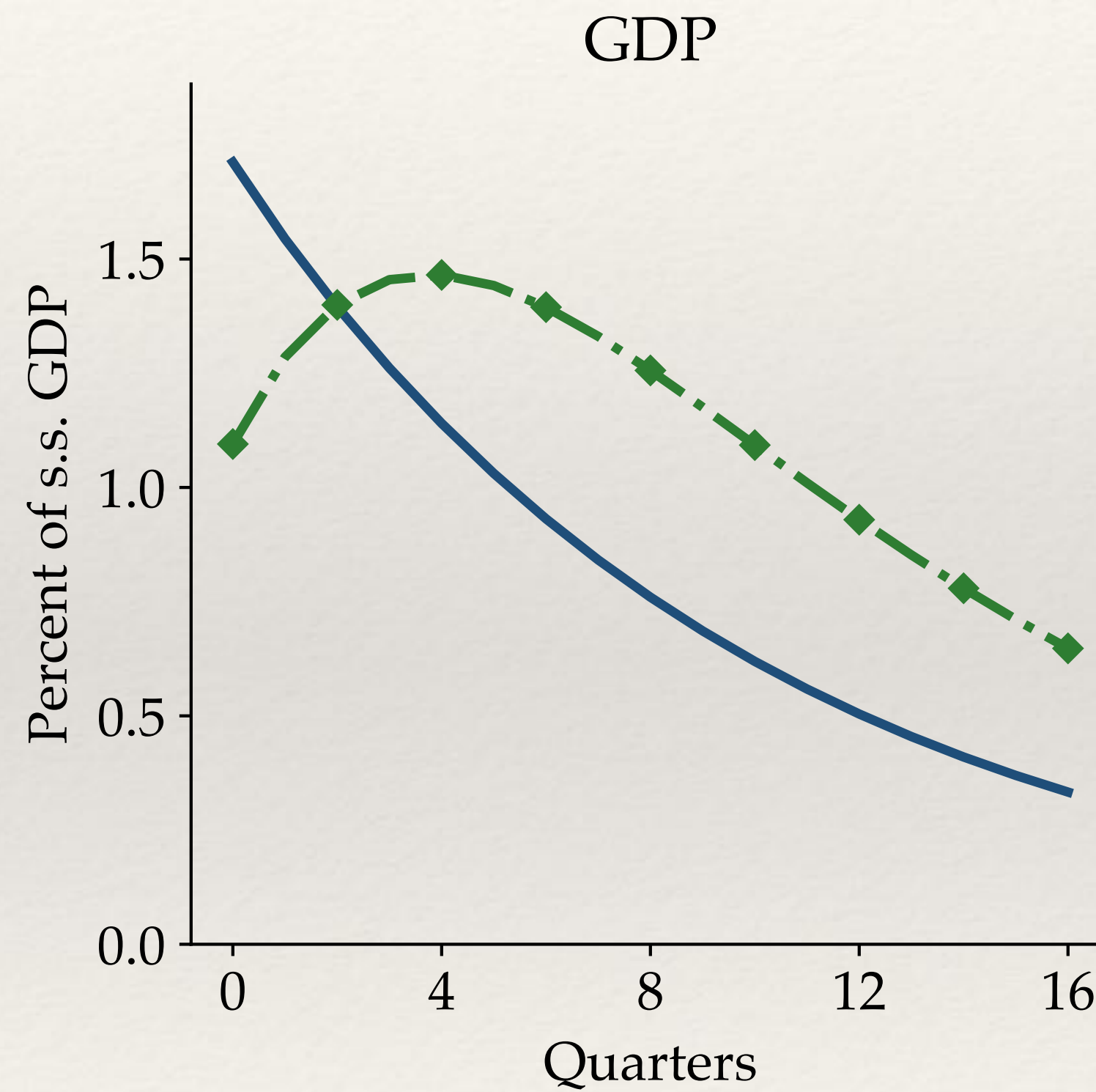
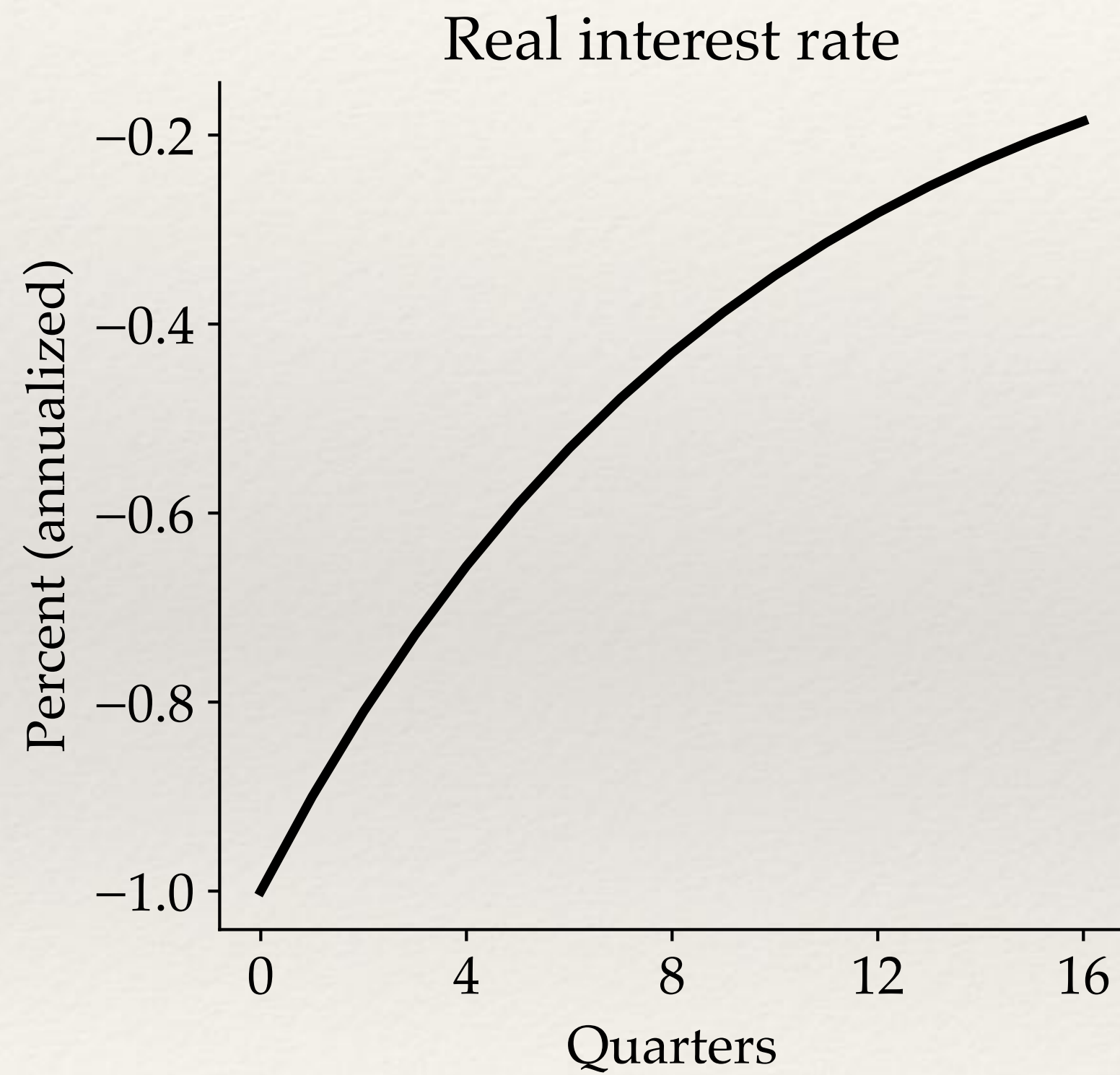
Overview

- ❖ Household side with $y_{it} = e_{it}^{(obs)} e_{it}^{(unobs)} Y_t$
 - ❖ $e_{it}^{(obs)}$, $e_{it}^{(unobs)}$ follow same process: $AR(1) + iid, \rho = 0.95$
 - ❖ assume 90% is known, 10% unknown
- ❖ Production $Y_t = N_t$, flex prices; sticky wages with unions in background
- ❖ Monetary policy sets real rate r_t directly
- ❖ Government issues debt, adjusts proportional taxes to balance the budget
- ❖ Standard quarterly calibration
- ❖ Note: In GE, **forecast matrix F** endogenous to Y_t , solve fixed point! (“infinite regress”)

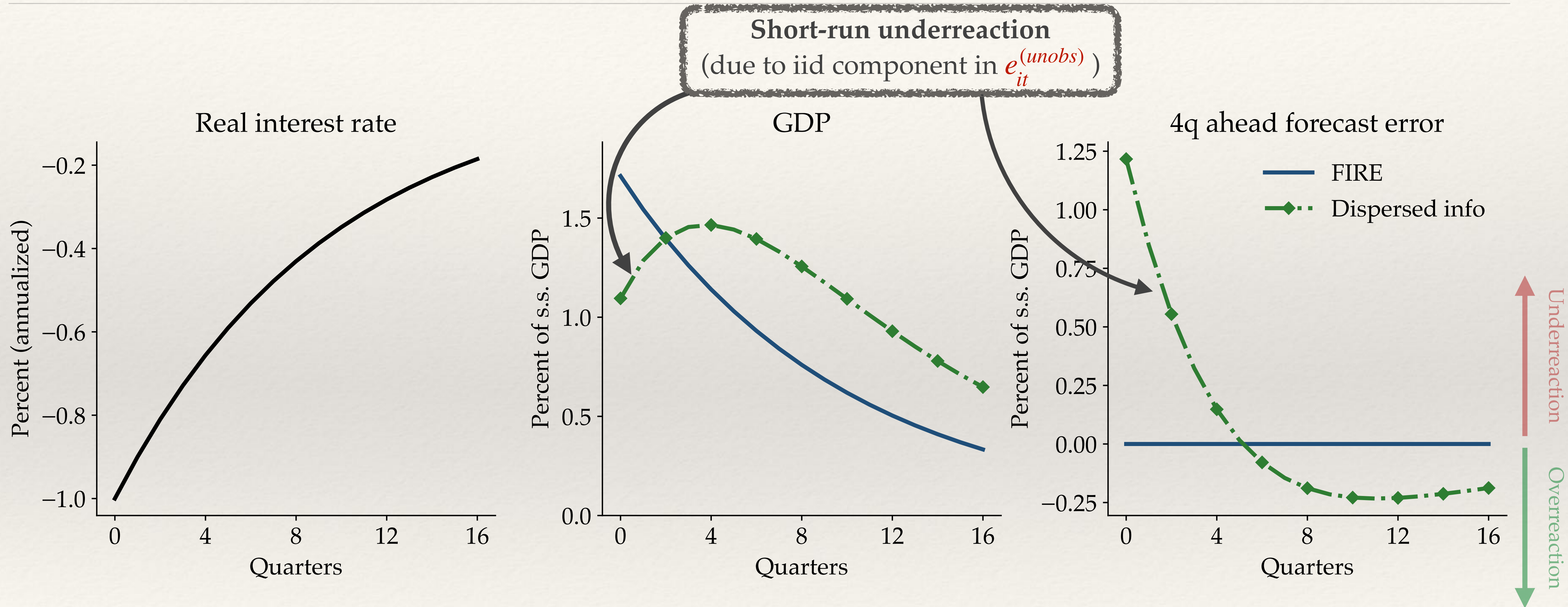
Comparison of our iMPCs with Colarietti et al



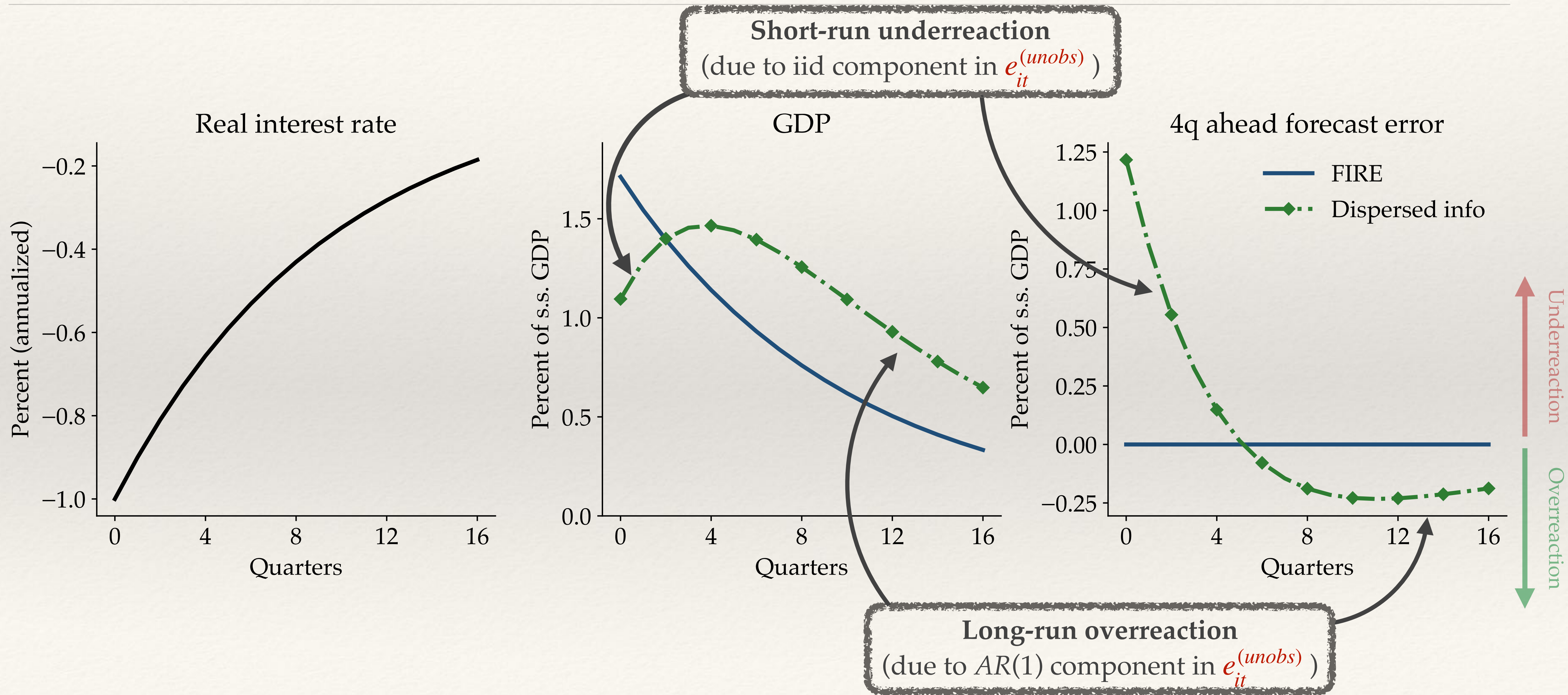
Monetary policy shock



Monetary policy shock



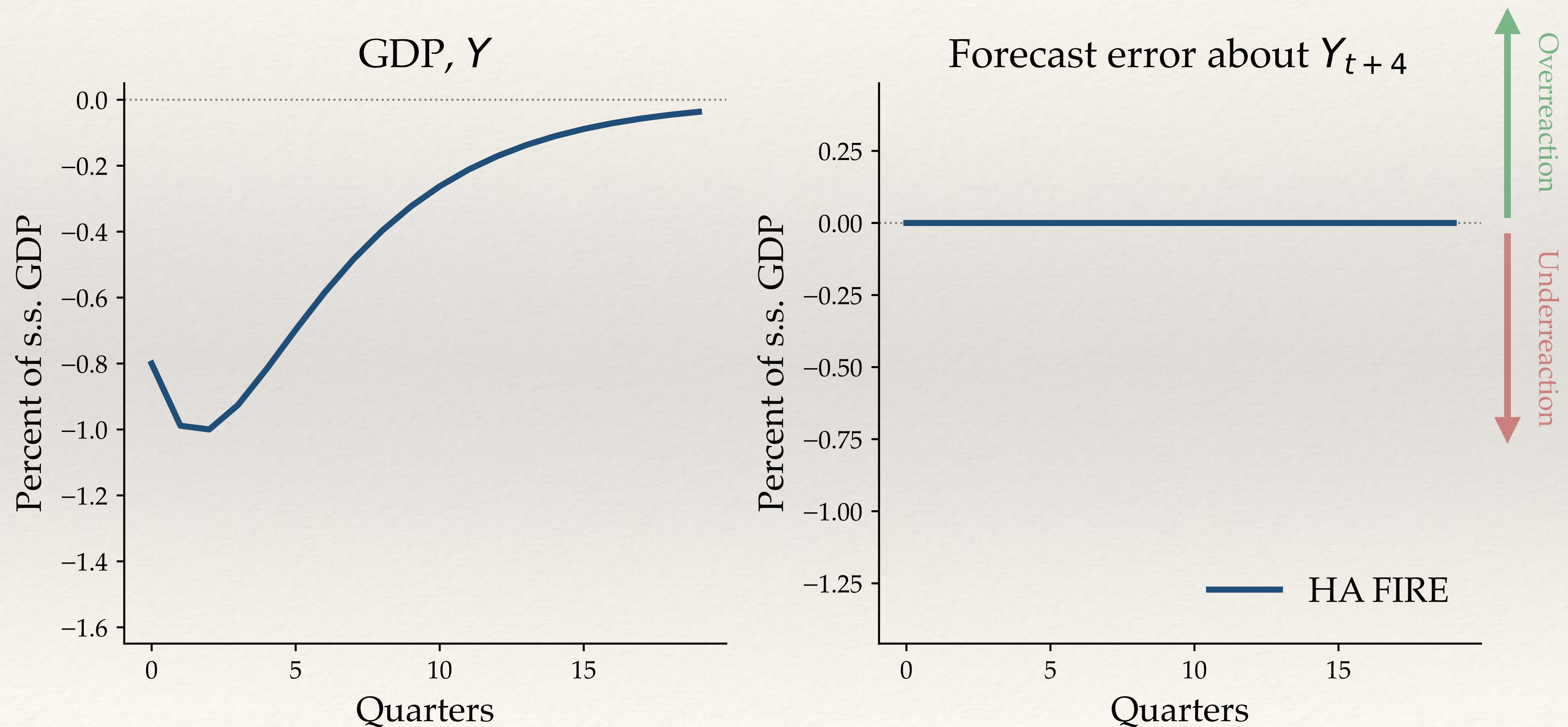
Monetary policy shock



Learning multiplier

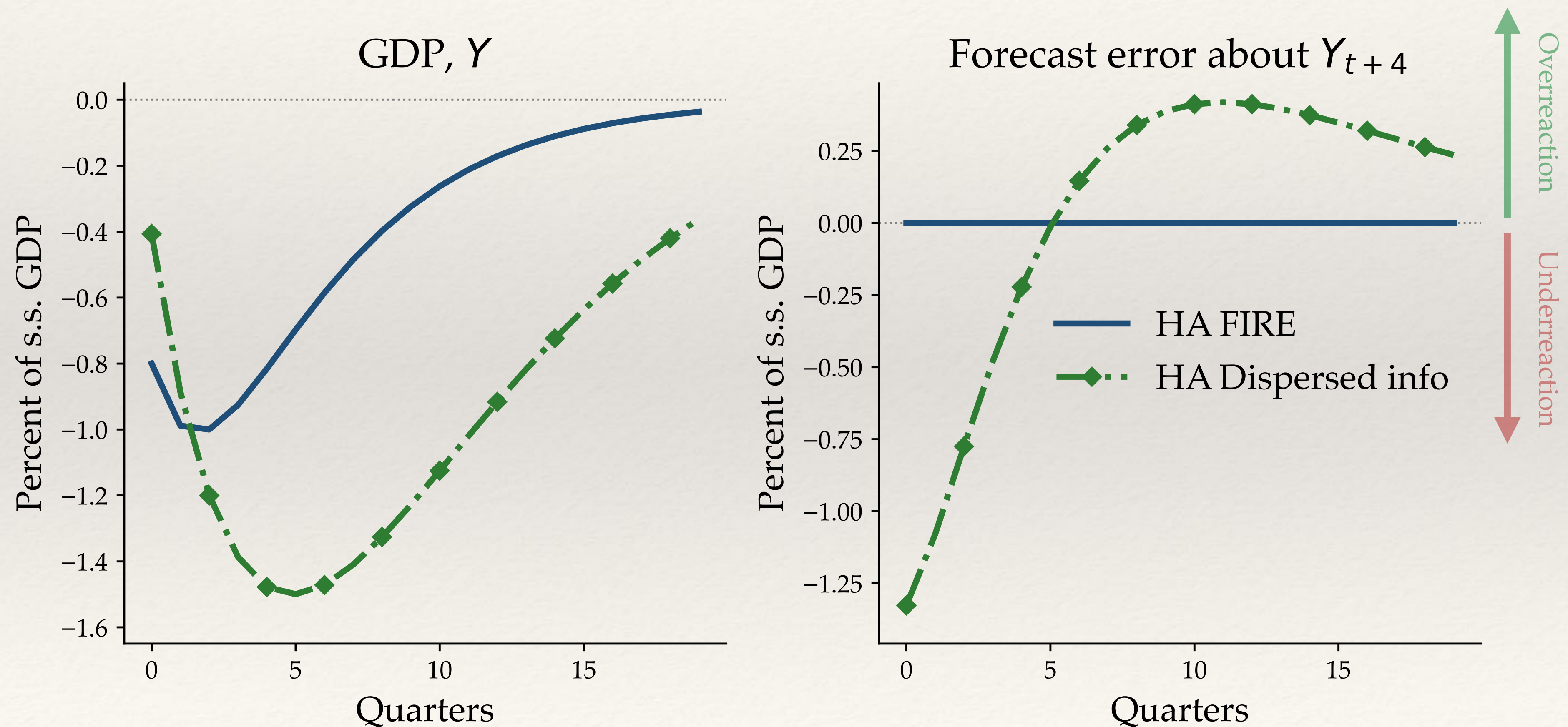
(1) Slow recoveries

- ❖ Shock β to generate a recession of a given size under FIRE.



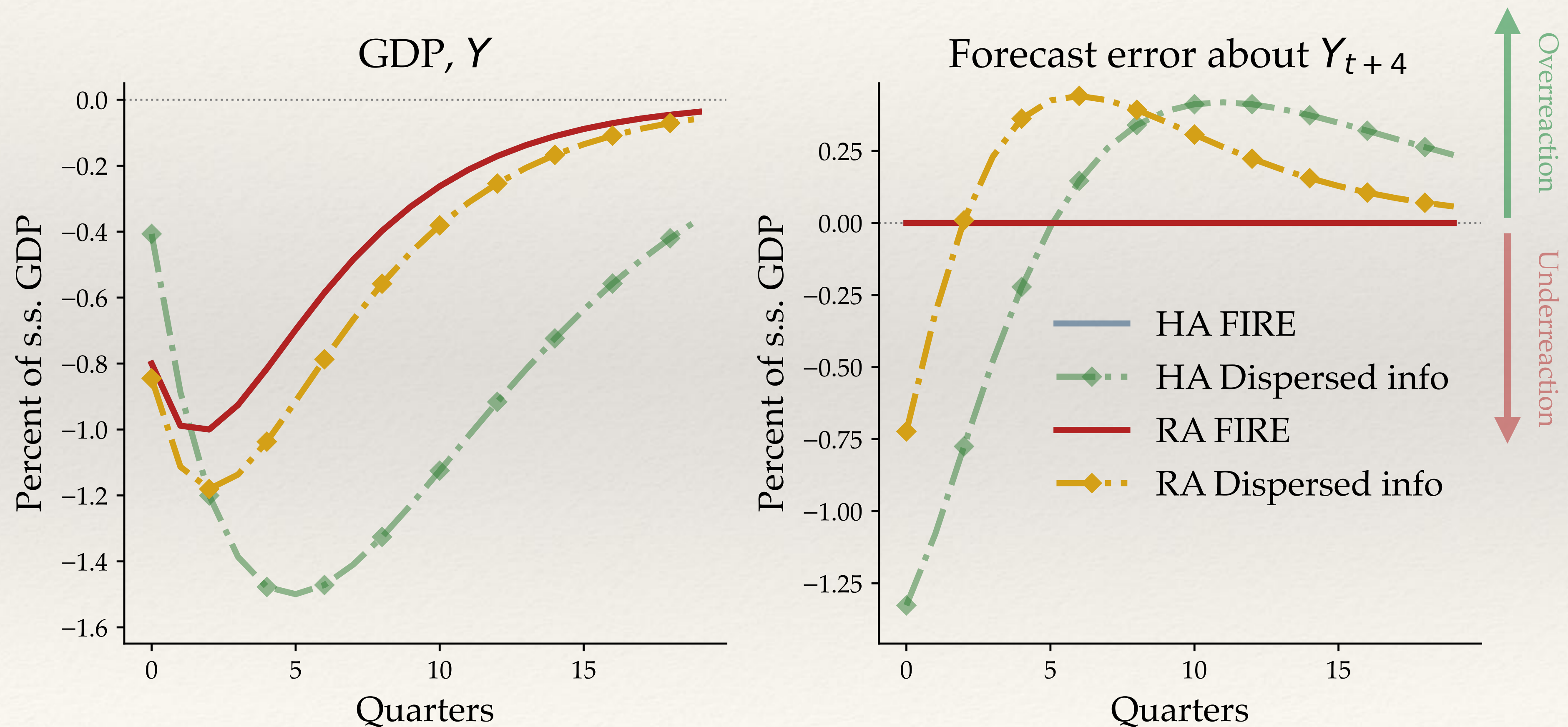
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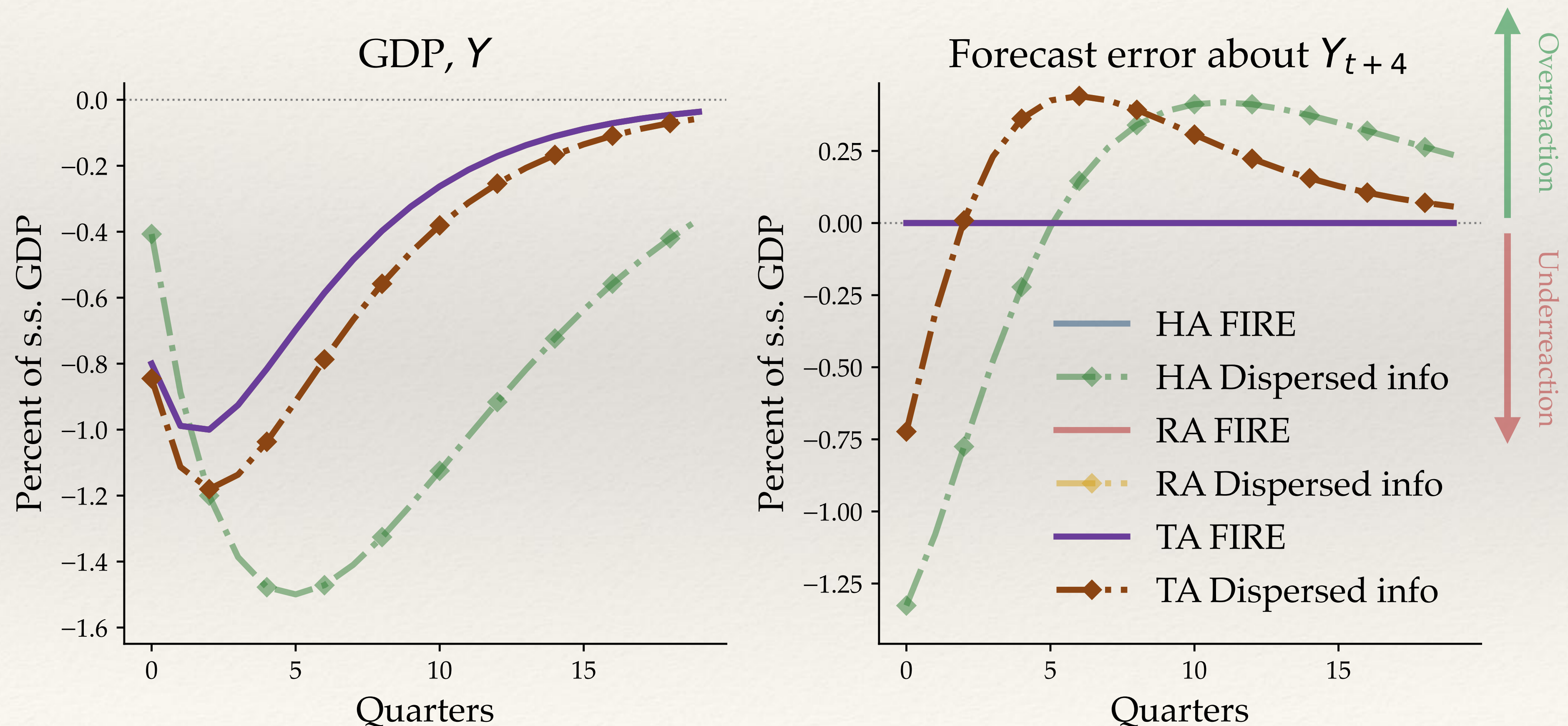
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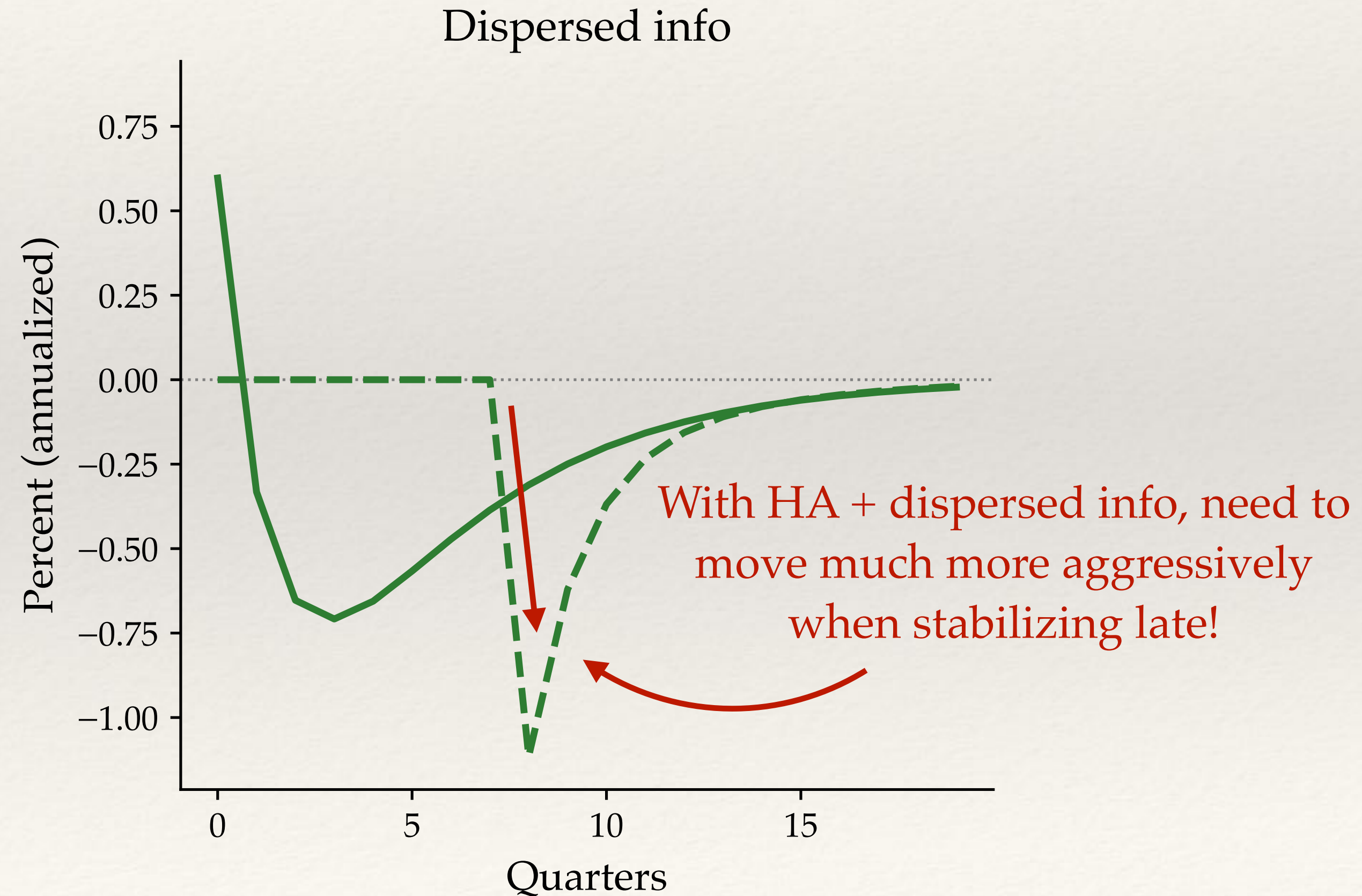
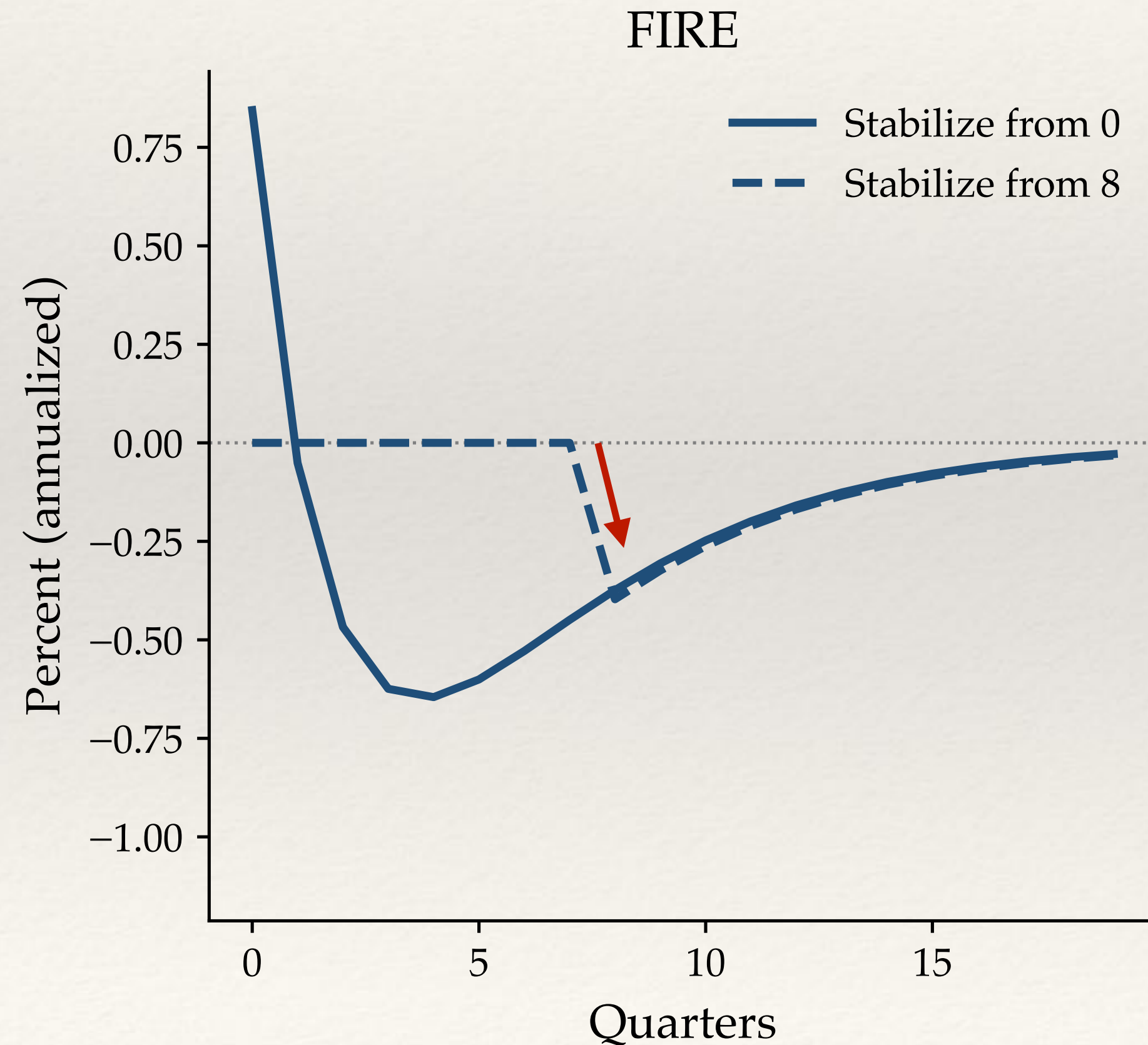
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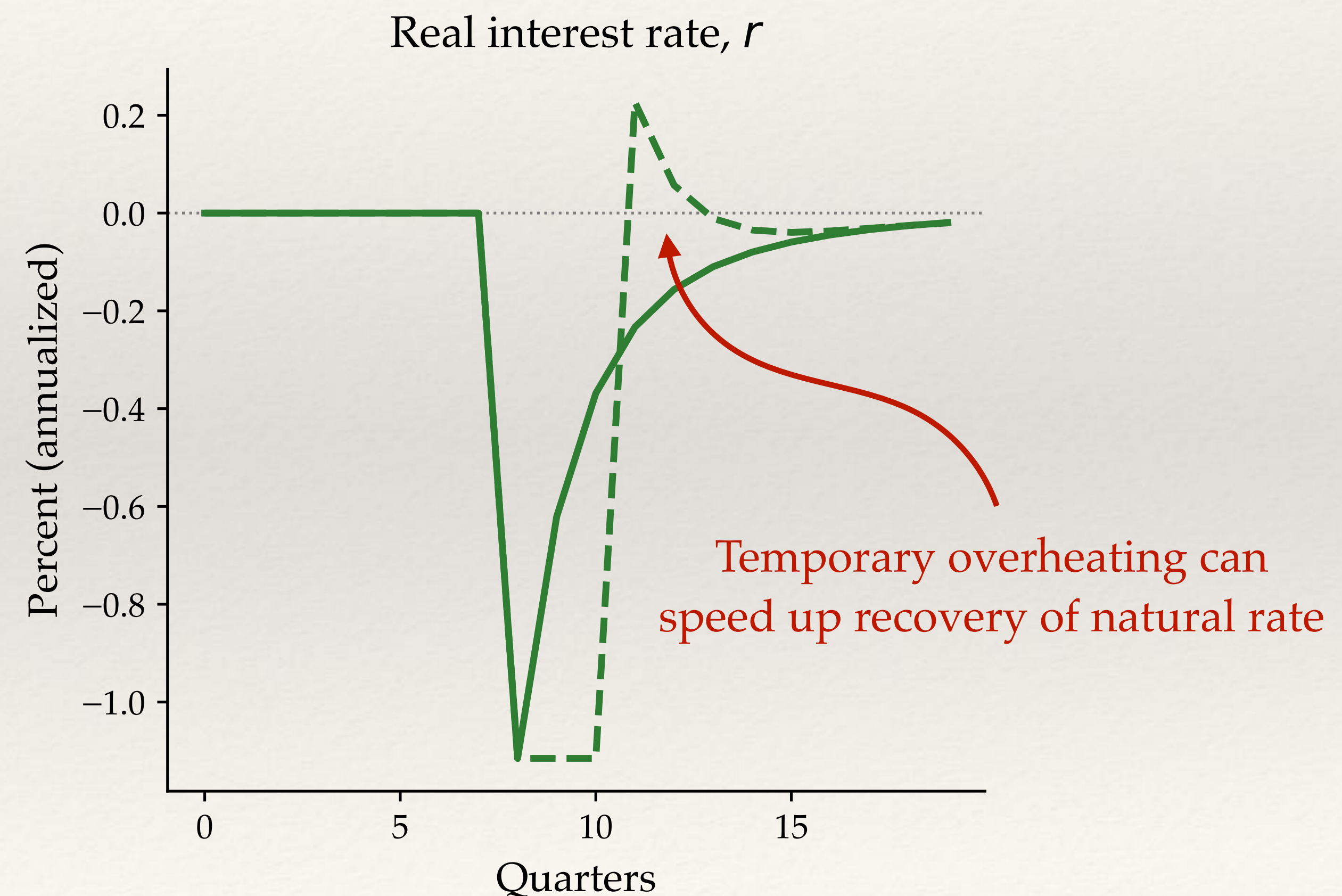
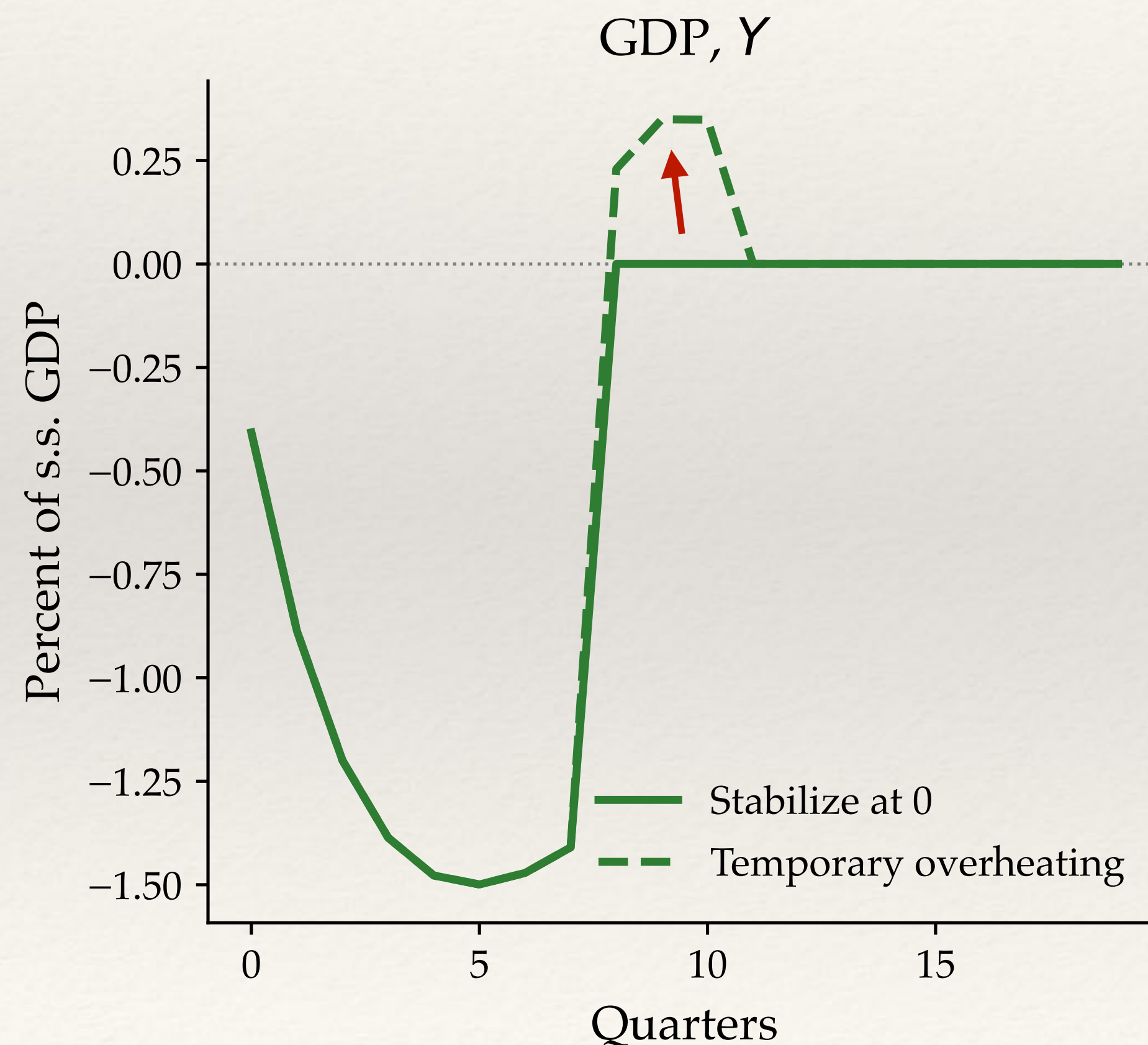
(2) Early stabilization vs. Late stabilization

- ❖ Same shock, compare natural rate path starting at $t = 0$ vs $t = 8$.



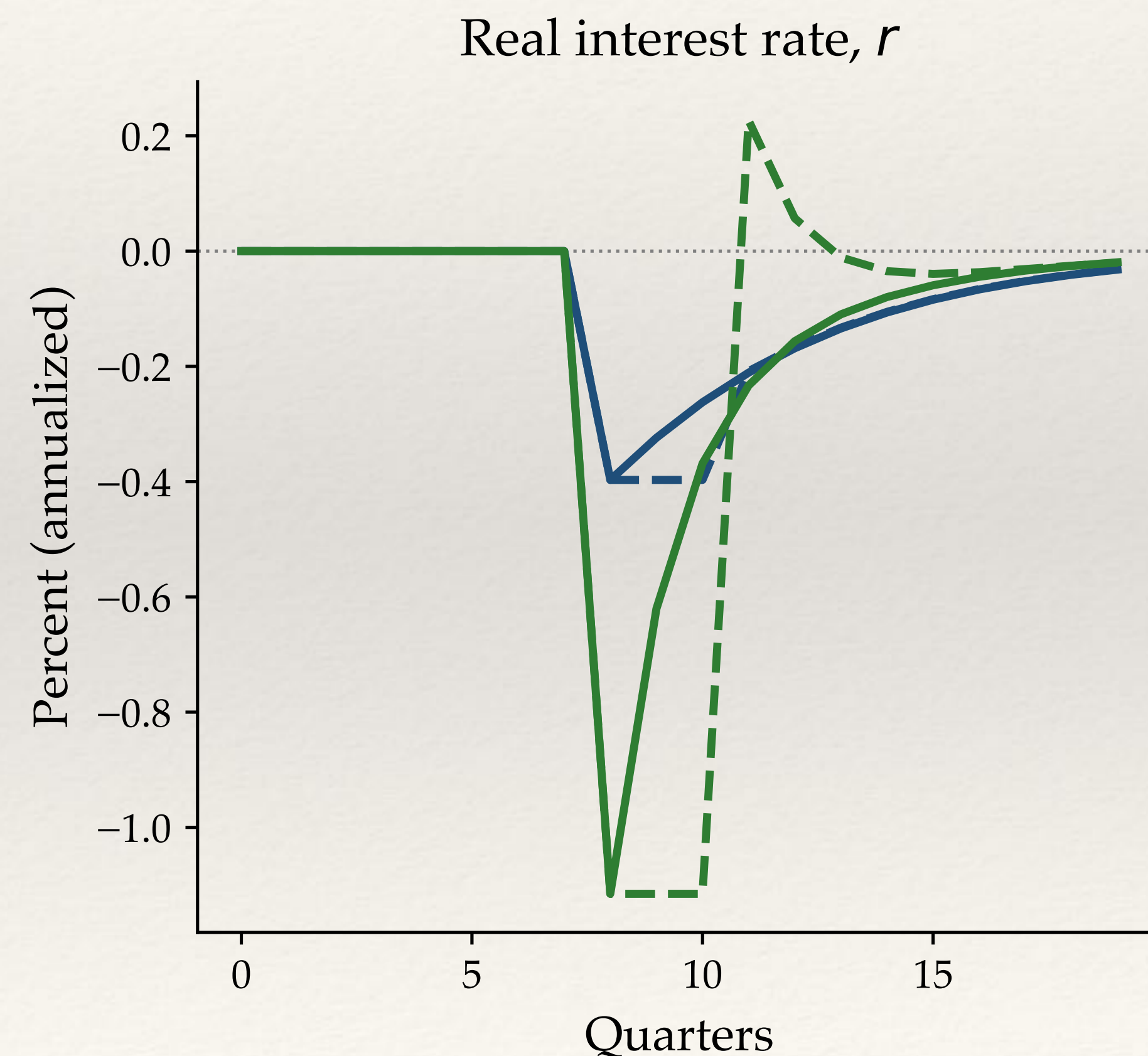
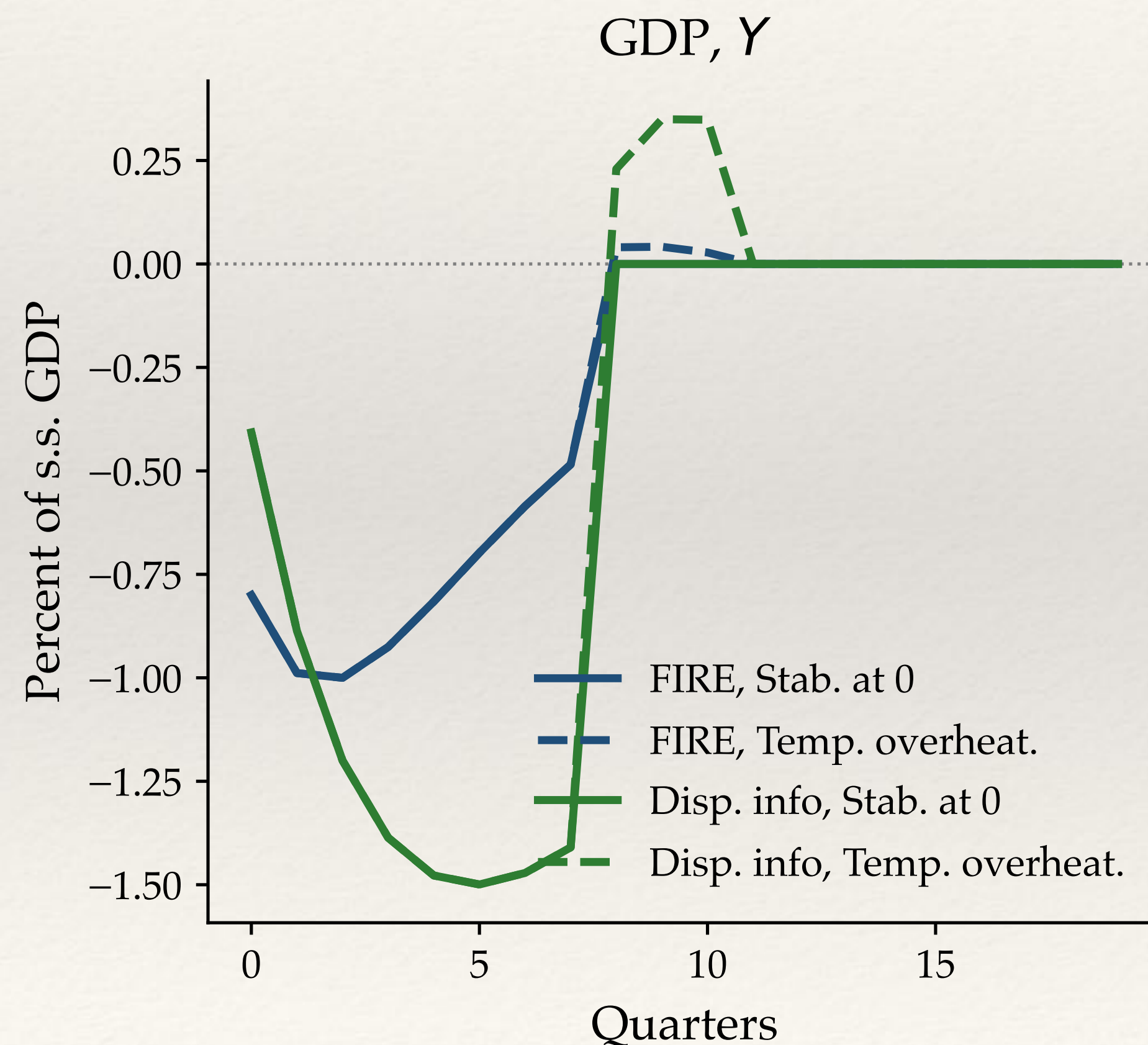
(3) Temporary overheating can raise natural rate

- ❖ Temporary overheating after recession raises natural rate faster.



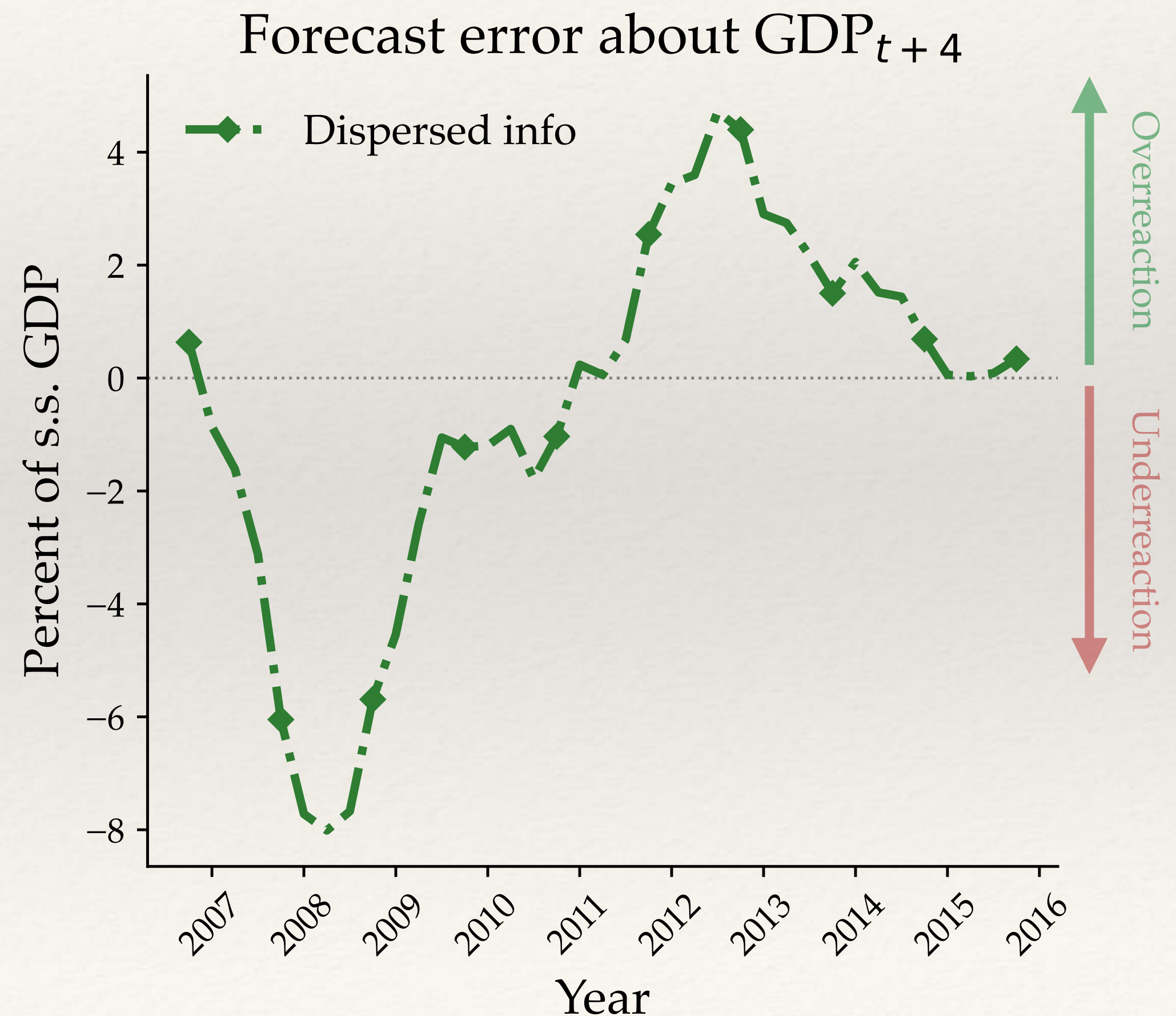
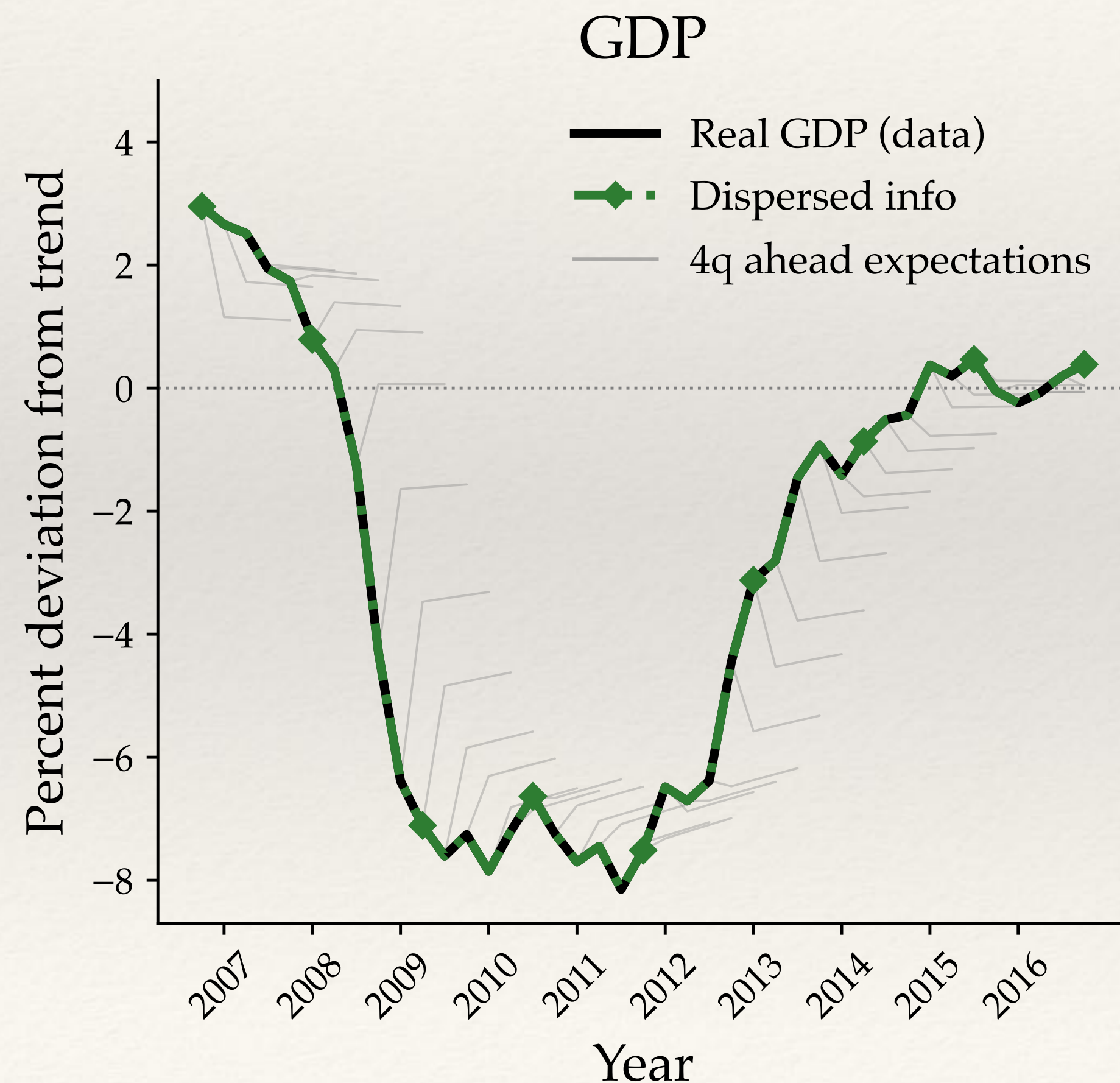
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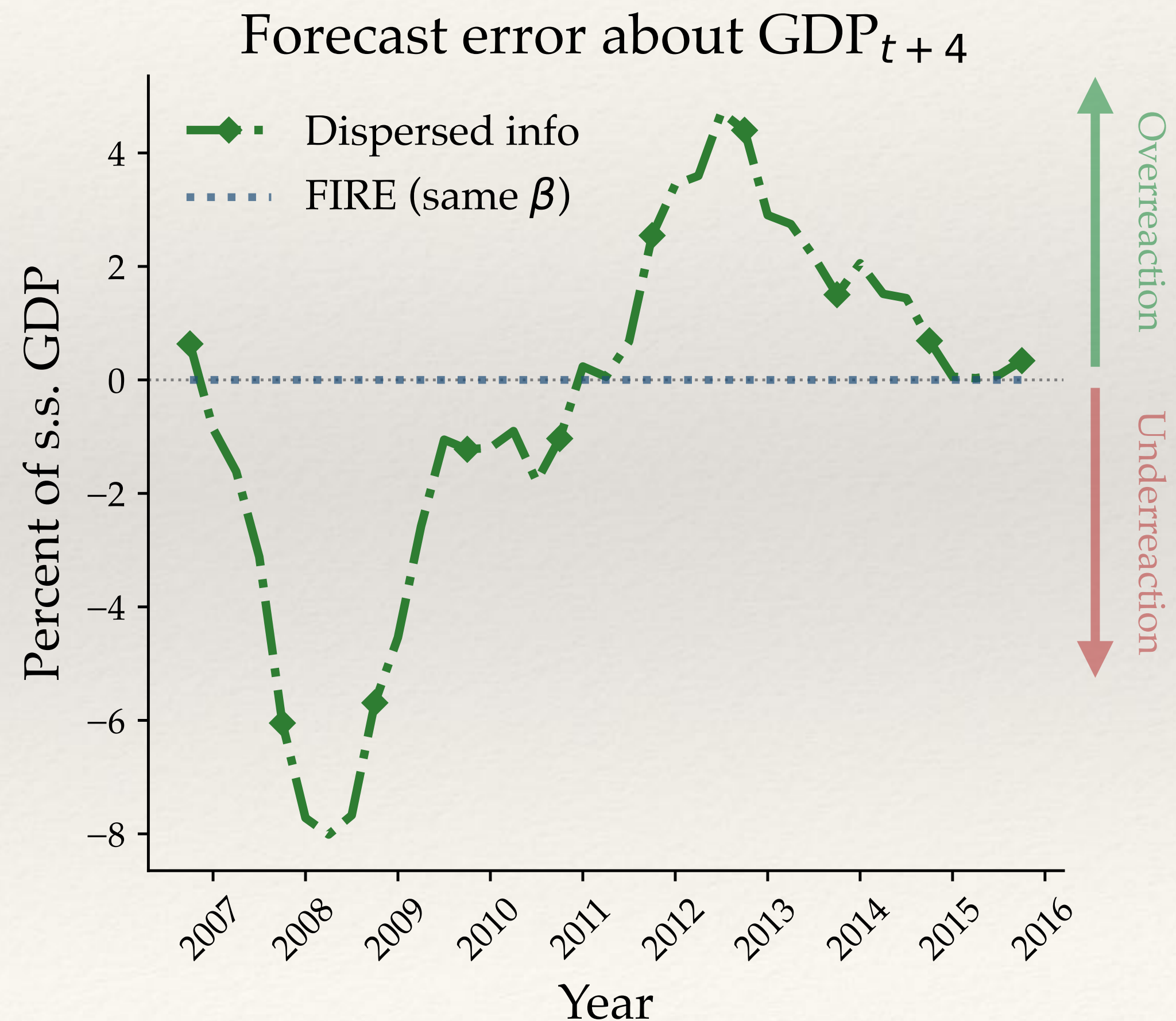
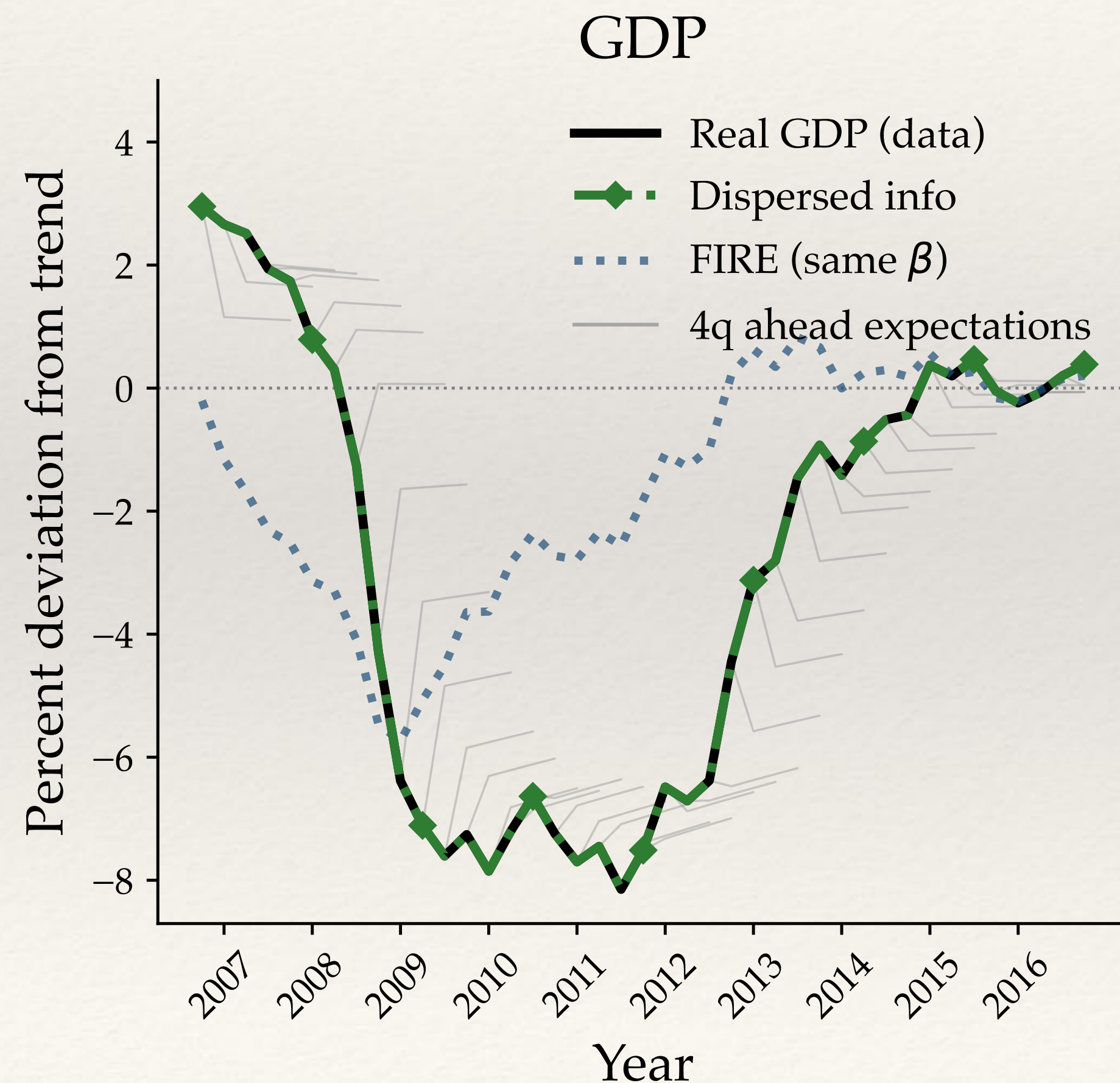
(4) Application to the Great Recession

- ❖ Match Great Recession with β shocks in the dispersed info model.



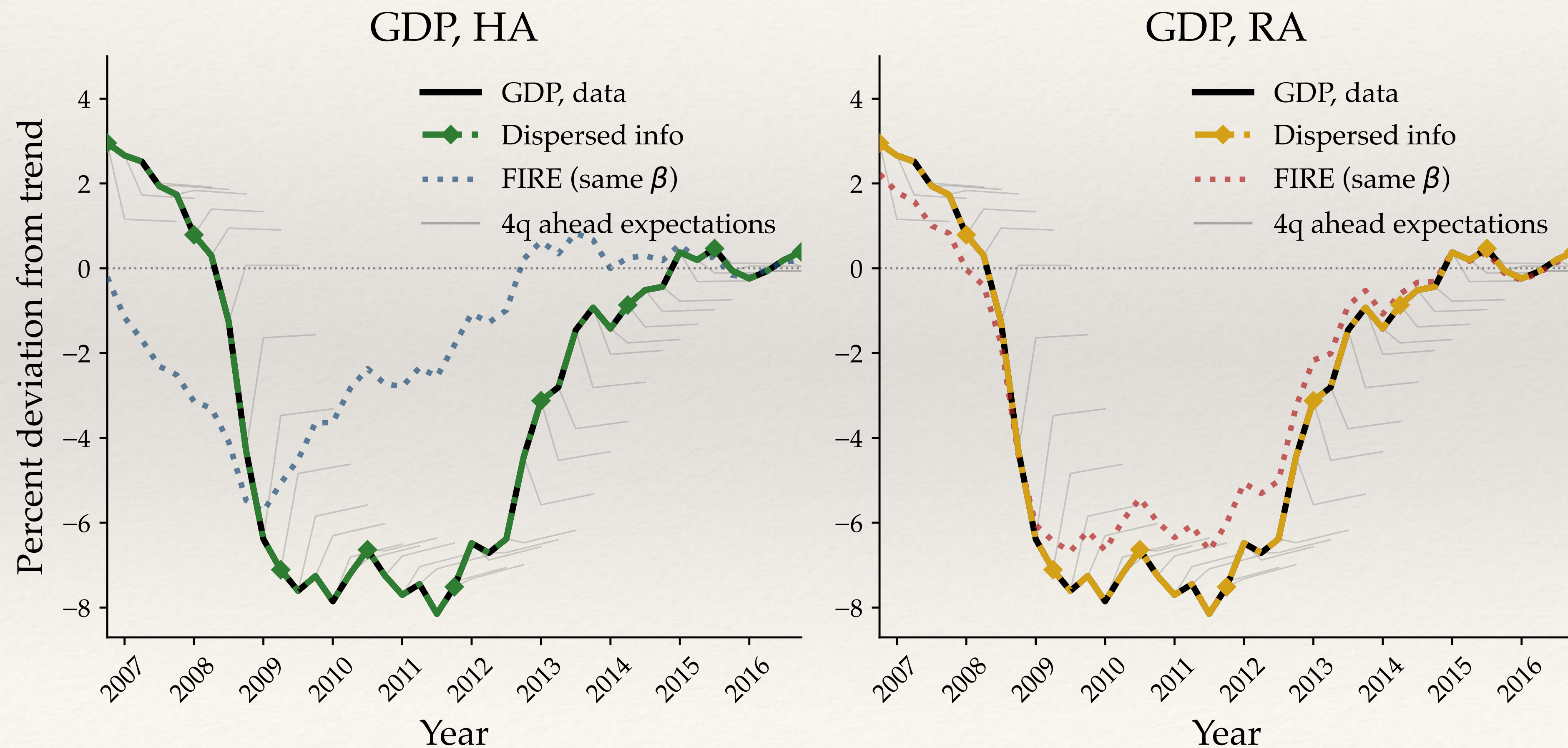
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- ❖ Match Great Recession with β shocks in the dispersed info model.



Conclusion

Learning in HANK

- ❖ New approach to embed **learning** in the sequence space
- ❖ Application to **learning about income** in HA models
- ❖ Powerful interaction with **intermediate MPCs** (not **RA**, **TA**)
- ❖ New “**learning multiplier**” in **HA models**