On Rational Inattention in Macroeconomics

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Motivation for "Optimal Sticky Prices under Rational Inattention"

- Individual prices change frequently and by large amounts.
  - Bils and Klenow (2004): In the U.S., half of all non-housing consumer prices last less than 4.3 months.
  - Klenow and Kryvtsov (2004): Conditional on the occurrence of a price change, the average absolute size of the price change is over 13%.
- The aggregate price level responds slowly to monetary policy shocks.
  - Uhlig (2005): Only about 25% of the long-run response of the U.S. GDP price deflator to a monetary policy shock occurs within the first year after the shock.

- This combination of empirical observations is difficult to explain with standard models of sticky prices.
  - Calvo model (Altig, Christiano, Eichenbaum and Linde, 2005).
  - Menu cost model (Golosov and Lucas, 2005).

What is rational inattention?

- Rational inattention is the idea that economic agents cannot pay attention to *all* available information but can decide *which* information to pay attention to.

- Agents optimally decide what to pay attention to, subject to a constraint on information flow.

"An optimizing trader will process those prices of most importance to his decision problem most frequently and carefully, those of less importance less so, and most prices not at all.

Of the many sources of risk of importance to him, the business cycle and aggregate behavior generally is, for most agents, of no special importance, and there is no reason for traders to specialize their own information systems for diagnosing general movements correctly."

(Lucas, 1977)

“Optimal Sticky Prices under Rational Inattention”

- Price setting firms optimally decide what to pay attention to, subject to a constraint on information flow.

- When idiosyncratic conditions are more variable or more important than aggregate conditions, firms pay more attention to idiosyncratic conditions than to aggregate conditions. Price reactions to idiosyncratic shocks are quick and strong whereas price reactions to nominal shocks are delayed and dampened.

- In addition, there are feedback effects.

Quantifying information flows

- Entropy of X with pdf $p(X)$ is defined by

$$H(X) = -E[\log_2 p(X)].$$

- Mutual information between a signal S and a state X

$$I(X;S) = H(X) - H(X|S).$$

- Information flow between stochastic processes

$$\mathcal{I}\left(\{X_t\};\{S_t\}\right) \equiv \lim_{T\to\infty}\frac{1}{T}I\left(X_1,...,X_T;S_1,...,S_T\right).$$

- If $\{X_t, S_t\}$ is a bivariate stationary Gaussian process, then

$$\mathcal{I}\left(\{X_t\};\{S_t\}\right) = -\frac{1}{4\pi}\int_{-\pi}^{\pi}\log_2\left[1-\mathcal{C}_{X,S}\left(\omega\right)\right]d\omega.$$

Bounding information flows

- Agents choose the joint stochastic process for $\{X_t, S_t\}$, subject to

$$\mathcal{I}\left(\{X_t\}\,;\{S_t\}\right) \leq \kappa.$$

- Agents choose the joint stochastic process for $\{X_t, Y_t\}$, where $\{Y_t\}$ is an action based on the signal $\{S_t\}$, subject to

$$\mathcal{I}\left(\{X_t\}\,;\{Y_t\}\right) \leq \kappa.$$

Model of optimal price setting

- A continuum of firms indexed by $i \in [0, 1]$.

- Firm i sells good i. Every period the firm sets the price of its good so as to maximize

$$E_{it}\left[\sum_{\tau=t}^{\infty} \beta^{\tau-t} \pi\left(P_{i\tau}, P_{\tau}, Y_{\tau}, Z_{i\tau}\right)\right].$$

- Firms take $\{P_t\}$, $\{Y_t\}$ and $\{Z_{it}\}$ as given.

- The information of firm i in period t is

$$s_i^t = \{s_i^1, s_{i2}, ..., s_{it}\}.$$

- Aggregate environment.
  - We postulate an exogenous stochastic process for nominal aggregate demand Q_t.
  - We assume that $q_t \equiv \ln Q_t - \ln \bar{Q}$ follows a stationary Gaussian process.
  - The aggregate price level is defined by

$$\ln P_t = \int_0^1 \ln P_{it} di.$$

- Idiosyncratic environment.
  - We postulate an exogenous stochastic process for the idiosyncratic state variables Z_{it}, $i \in [0, 1]$.
  - We assume that the $z_{it} \equiv \ln Z_{it} - \ln \bar{Z}$ follow a common stationary Gaussian process.
  - We assume that the $\{z_{it}\}$ are pairwise independent and independent of $\{q_t\}$.

- Firms decide what to pay attention to. In period zero firm i solves:

$$\max_{\{s_{it}\}\in\Gamma} E\left[\sum_{t=1}^{\infty}\beta^t \pi\left(P_{it}^*, P_t, Y_t, Z_{it}\right)\right],$$

subject to

$$P_{it}^* = \arg\max_{P_{it}\in\mathbb{R}_+} E[\pi\left(P_{it}, P_t, Y_t, Z_{it}\right)|s_i^t],$$

and

$$\mathcal{I}\left(\{P_t\}, \{Y_t\}, \{Z_{it}\}; \{s_{it}\}\right) \leq \kappa.$$

- Γ is the set of all signal processes with the properties:
  - signals contain no information about future innovations,
  - $\{s_{it}, p_t, y_t, z_{it}\}$ is a stationary Gaussian vector process,
  - $s_{it} = (s_{1it}, s_{2it})$, where $\{s_{1it}, p_t, y_t\}$ and $\{s_{2it}, z_{it}\}$ are independent,
  - all noise in the signals is idiosyncratic.

Figure 1: Impulse responses of an individual price to an innovation in the idiosycratic state variable, benchmark economy

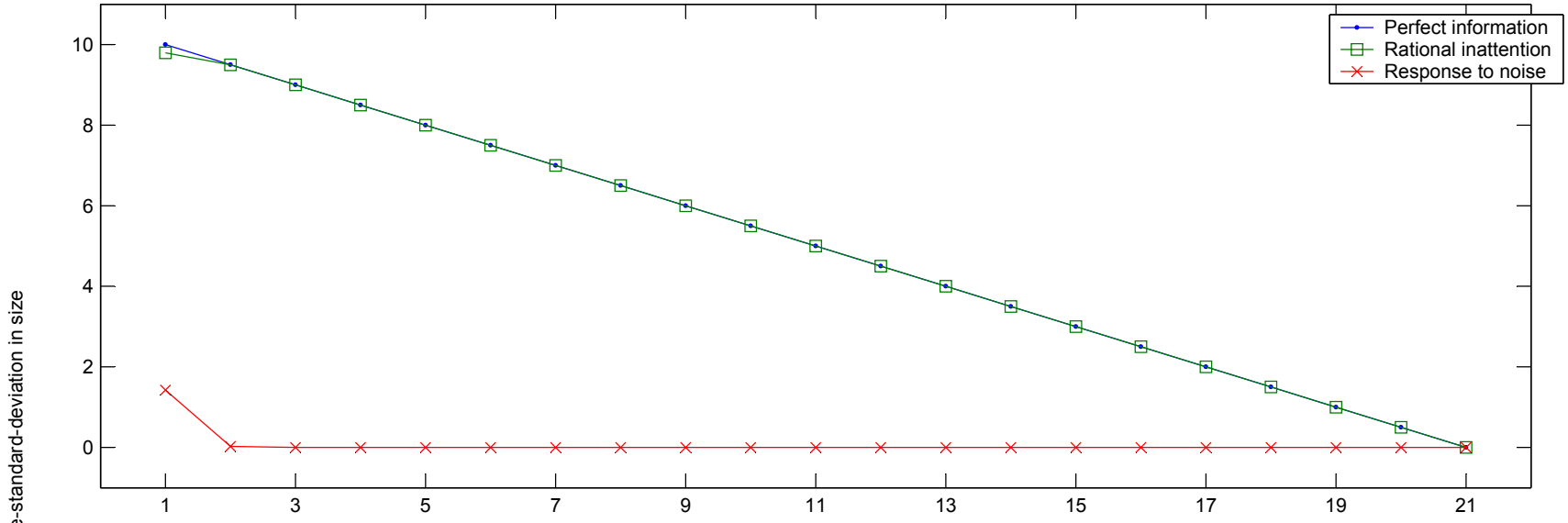
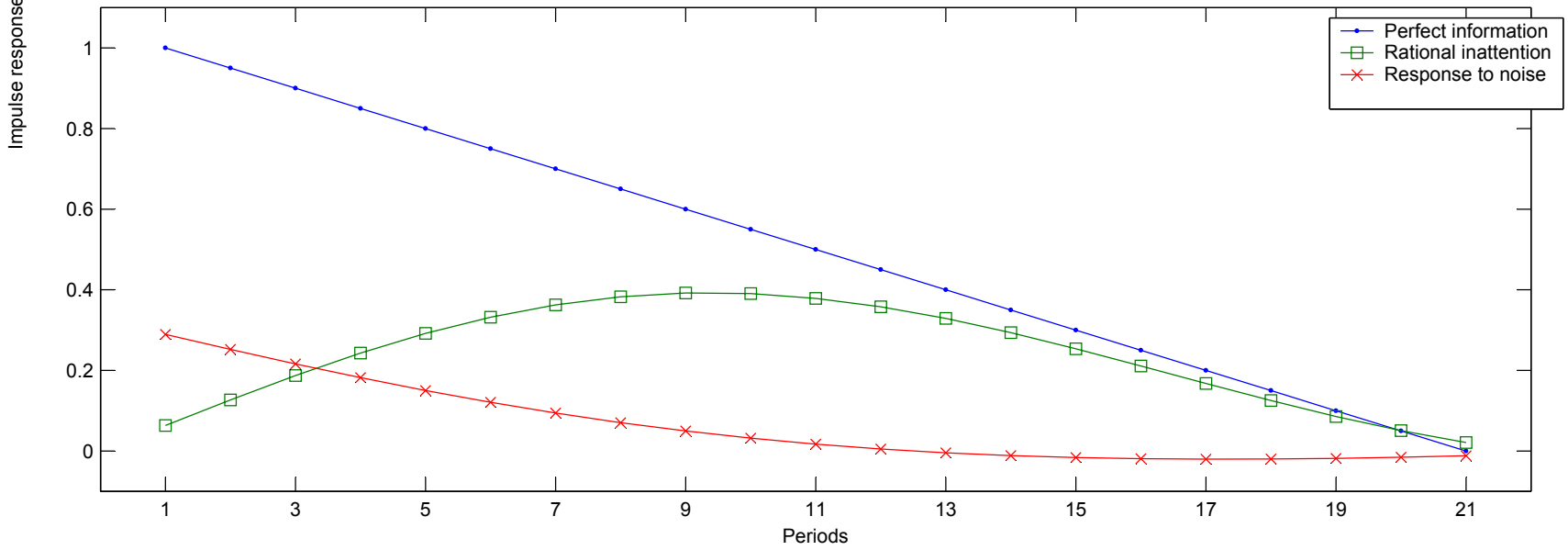


Figure 2: Impulse responses of an individual price to an innovation in nominal aggregate demand, benchmark economy



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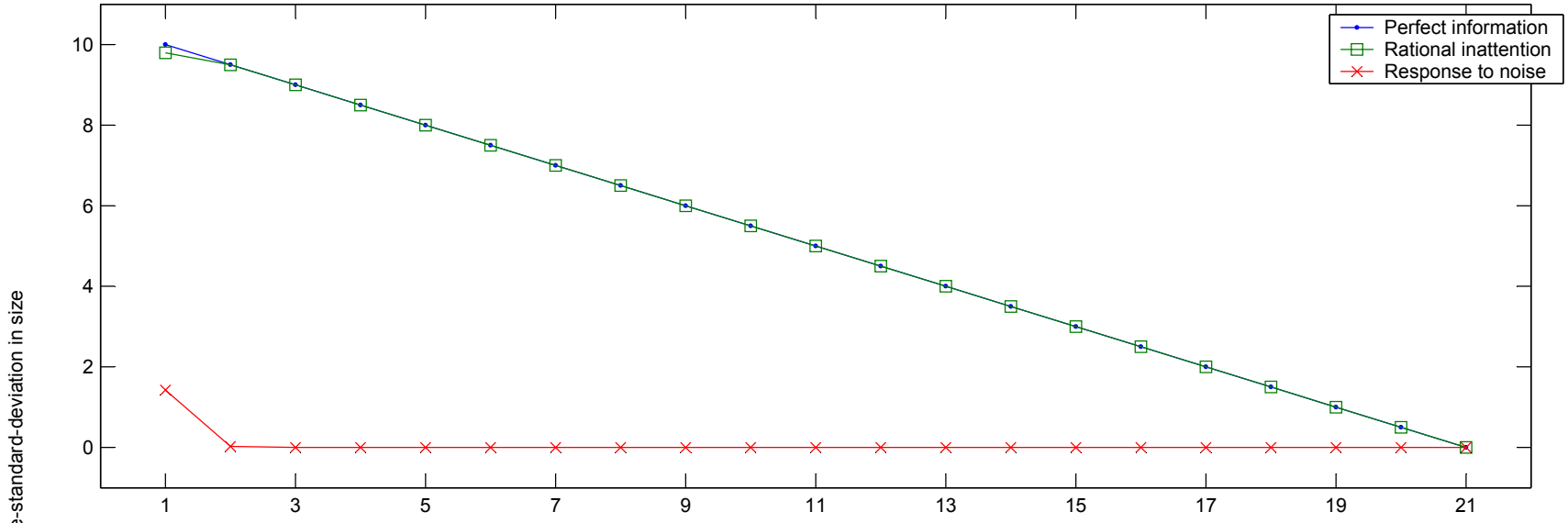

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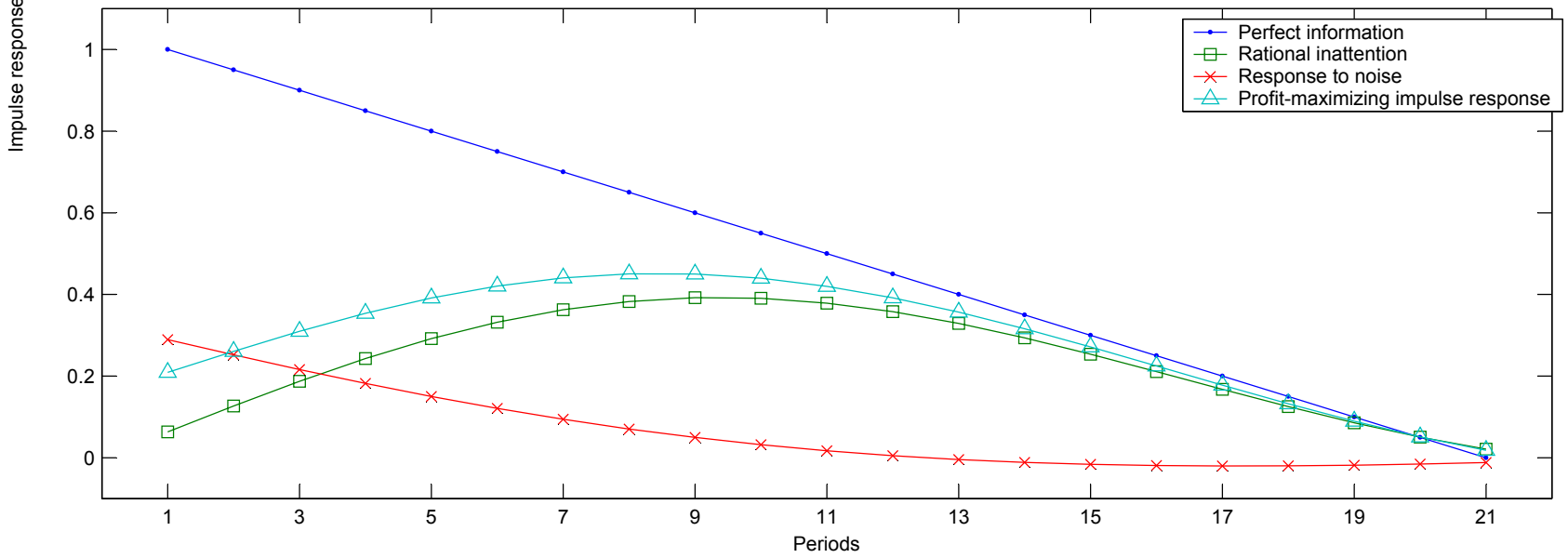

- Increasing the variance of the idiosyncratic state variable makes the impulse response to a nominal shock more sticky.

- Increasing the variance of nominal aggregate demand makes the Phillips curve steeper and makes real volatility go up.

- Decreasing the serial correlation of nominal aggregate demand increases losses in profits due to imperfect tracking.

Conclusion from "Optimal Sticky Prices"

- That price changes are frequent and large does *not* imply that the aggregate price level must react fast to monetary policy shocks.

- Standard sticky price models versus a rational inattention model.

Implications for monetary policy

- Stabilizing monetary policy is good.
- "Interest rate smoothing" is good.
- The allocation of attention changes as monetary policy changes.
  - It matters how the central bank communicates with markets.
- Monetary policy has different effects on different sectors.

Beyond "Optimal Sticky Prices"

- Stickiness in macro data other than the aggregate price level.

- Other areas of economics where idiosyncratic uncertainty dominates aggregate uncertainty.

- Current research projects.
  - A DSGE.
  - Comparing the model in "Optimal Sticky Prices" to data.