A Macroeconomy with Intuitive Thinkers

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Food for Thought

1. What would be your forecast of US output and inflation for Q1 2025?
2. How about for Q1 2030?
3. Are these easy or difficult questions?

Starting Point

Dynamic stochastic general equlibrium (**DSGE**) models often rely on the assumption of *rational expectations*, i.e. agents have precise (and on average correct) answers to the above questions.

Could we (slightly) adjust expectation formation in a well-established DSGE model such that:

- Agents' "forecasting" becomes more realistic?
- We retain tractability, parsimony?
- We better match interesting empirical phenomena?

We **combine**:

1. A baseline New Keynesian model from [Galí, 2015, Chapter 3]
2. Substitution heuristic/anchoring from Kahneman [2011], Tversky and Kahneman [1974]

We understand agents' *intuitions* as instances of the substitution heuristic:

> If a satisfactory answer to a hard question is not found quickly, System 1 will find a related question that is easier and will answer it. I call the operation of answering one question in place of another substitution.
>
> *Thinking Fast and Slow* – Kahneman [2011]

Our Approach: Dual System Processing

When solving a linear difference model, agents substitute $\mathbb{E}_t[\cdot]$ for $\mathbb{E}_t^D[\cdot]$:

$$\mathbf{X}_t = \mathbf{A}\,\mathbb{E}_t\left[\mathbf{X}_{t+1}\right] + \mathbf{u}_t \quad \rightarrow \quad \mathbf{X}_t = \mathbf{A}\,\mathbb{E}_t^D\left[\mathbf{X}_{t+1}\right] + \mathbf{u}_t \tag{1}$$

- Example: New Keynesian DSGE with $\mathbf{X}_t \equiv (\text{inflation}_t, \text{output deviation}_t)$, fundamental shocks $\mathbf{u}_t$.

The dual-processing expectations are defined recursively as:

$$\mathbb{E}_t^D\left[\begin{pmatrix}\hat{y}_{t+1}\\ \pi_{t+1}\end{pmatrix}\right] \equiv \underbrace{\delta\left\{\mathbf{A}\mathbb{E}_t^D\left[\begin{pmatrix}\hat{y}_{t+2}\\ \pi_{t+2}\end{pmatrix}\right] + \mathbb{E}_t\left[\mathbf{u}_{t+1}\right]\right\}}_{\text{rigorous system}} + \underbrace{(1-\delta)\begin{pmatrix}s^{\hat{y}}_{(t)}\\ s^{\pi}_{(t)}\end{pmatrix}}_{\text{intuitive system}} \tag{2}$$

Convenient properties:

- $\delta = 1 \Rightarrow$ Full information rational expectations.
- $s_t^y = s_t^\pi = 0\ \forall t \Rightarrow$ New Keynesian DSGE with *cognitive discounting* (Gabaix [2020]).
- $\delta \Rightarrow$ The fraction of the true model that goes into the expectations recursion.
- $1-\delta \Rightarrow$ The weight of intuitions (shrinking expectations towards the "anchor": s_t).

An "Intuitive Model"

Example: All good/bad in one heuristic.

- *High* growth is "good" and *low* inflation is "good", so cognition packs them together.
- Microfoundations: Associative memory (Bordalo et al. [2020]).

Formalised as VAR(1) for $s_t = (s_t^{\hat{y}}\ s_t^{\pi})'$ with $Cov(\eta_t^{\hat{y}}, \eta_t^{\pi}) \neq 0$.

$$s_t = \Phi s_{t-1} + \eta_t \tag{3}$$

Empirical importance:

- Negative correlation between inflation and output expectations in surveys (Candia et al. [2020]).
- Agents' thinking about shock propagation more focused on the supply side (Andre et al. [2022]).

Theoretical usefulness:

- Policy relevance: The process for s_t could be influenced by (monetary) policy (communication).
- Flexibility: Permits tractable incorporation of various intuitive models.

Dual System Processing in Action (Setting: [Galí, 2015, Chapter 3])

Thinking Slow and Fast:

1. Rigorous system (consciousness): Uses the New Keynesian "template" to iterate $\mathbb{E}_t\left[\mathbf{X}_{t+1}\right]$.
2. Intuitive system (subconsciousness): Introduces "sentiments" (anchor, gut-feelings).
3. The interplay between the two systems ctd. ad infinitum (constant relative importance: $\delta/(1-\delta)$).

$$\begin{aligned}
\mathbf{X}_t &= \mathbf{A}\mathbb{E}_t\left[\mathbf{X}_{t+1}\right] + \mathbf{u}_t\\
\mathbb{E}_t\left[\mathbf{X}_{t+1}\right] &= \mathbf{A}\mathbb{E}_t\left[\mathbf{X}_{t+2}\right] + \mathbb{E}_t\left[\mathbf{u}_{t+1}\right]\\
\mathbb{E}_t\left[\mathbf{X}_{t+1}\right] &\rightarrow \delta(\mathbf{A}\mathbb{E}_t\left[\mathbf{X}_{t+2}\right] + \mathbb{E}_t\left[\mathbf{u}_{t+1}\right]) + (1-\delta)\mathbf{s}_{(t)}\\
&\dots\\
\mathbb{E}_t^D\left[\mathbf{X}_{t+1}\right] &= \delta\mathbb{E}_t\mathbf{u}_{t+1} + \delta^2\mathbf{A}_t\mathbb{E}_t\left[\mathbf{u}_{t+2}\right] + \dots + (1-\delta)\mathbf{s}_{(t)} + (1-\delta)\delta\mathbf{A}\mathbf{s}_{(t)} + \dots
\end{aligned}$$

Will have a unique unique solution if:

$$\delta < \phi_\pi + \frac{1-\beta\delta}{\kappa}\phi_y + \frac{\sigma}{\kappa}\left[1-\delta(1+\beta(1-\delta))\right]. \tag{4}$$

Output and inflation evolve as a linear combination of fundamental shocks and sentiments:

$$y_t^D = \Psi_{ya}a_t + \Psi_{yv}v_t + \Psi_{yz}z_t + (1-\delta)\Gamma\Omega\left[\sigma(1-\delta\Omega\beta(\sigma+\phi_y+\kappa\phi_\pi))s_t^y + (1-\beta\phi_\pi)s_t^\pi\right] \tag{5}$$

$$\pi_t^D = \Psi_{\pi a}a_t + \Psi_{\pi v}v_t + \Psi_{\pi z}z_t + (1-\delta)\Gamma\Omega\left[\sigma\kappa s_t^y + [\kappa+\beta(\sigma+\phi_y) - \delta\Omega\sigma\beta(\kappa\phi_\pi+\sigma+\phi_y)]s_t^\pi\right], \tag{6}$$

Evidence for Intuitive Models

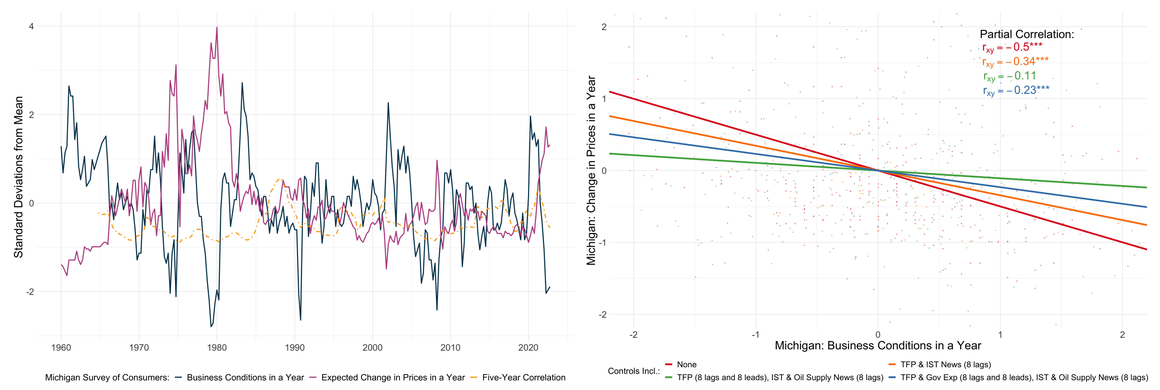

Figure 1. Associating High Inflation with Negative Economic Outlook? The "Stagflationary View".

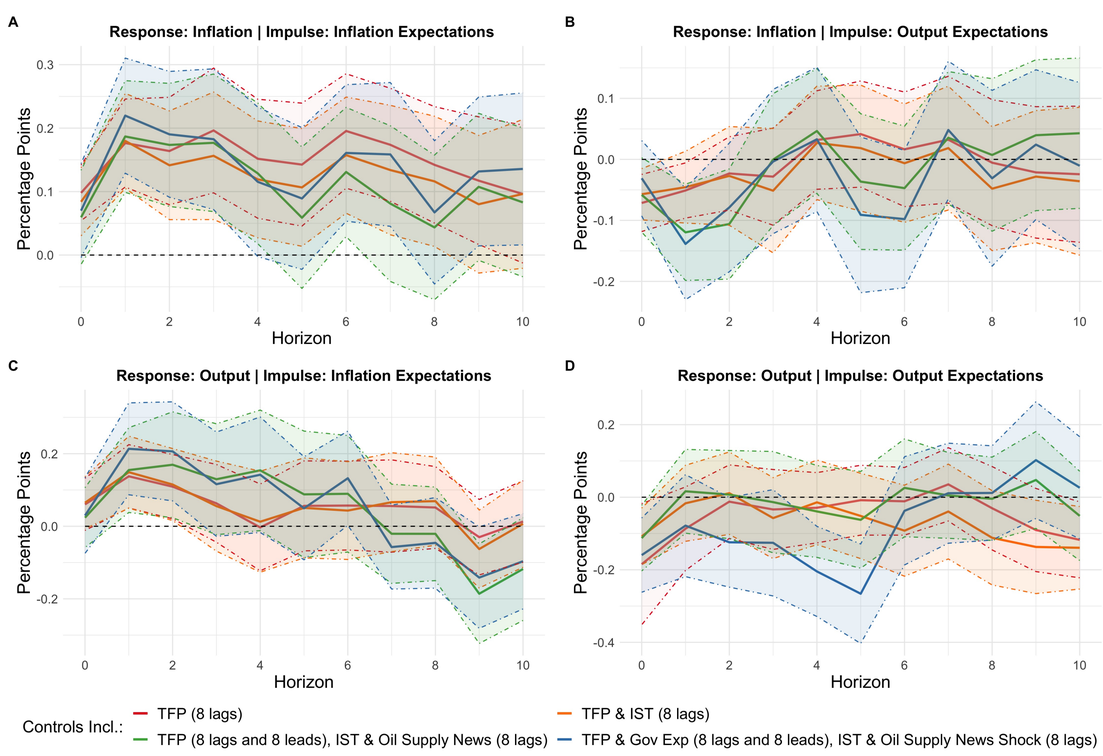

Figure 2. Local Projections of Identified "Sentiment" Shocks

Preliminary Quantitative Results

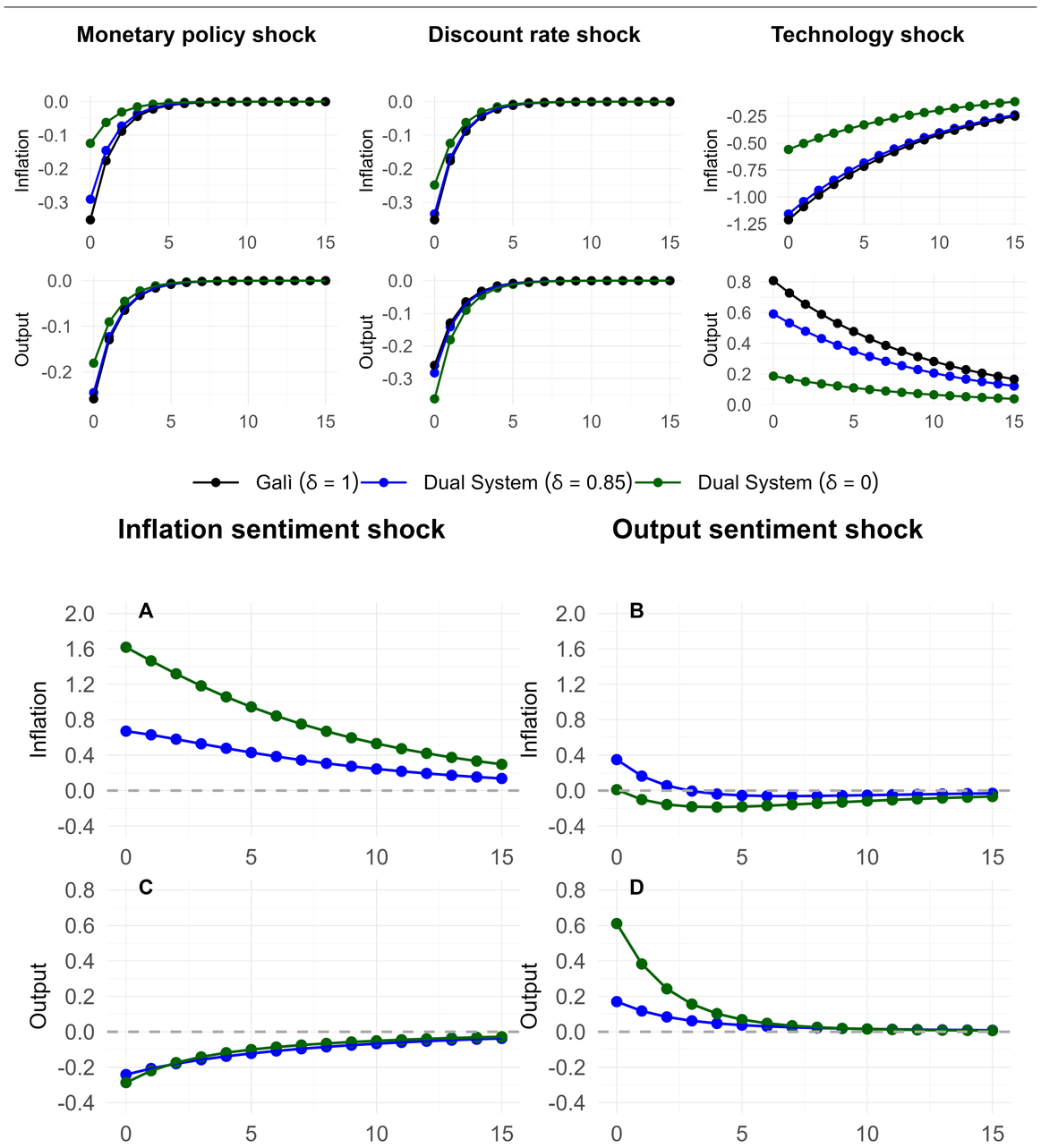

Figure 3. Impulse Responses to Fundamental and Sentiment Shocks for Different Values of δ

Outlook

1. Further development of microfoundations for the intuitive model and δ.
2. Application of our framework to large(r) DSGE models. Heterogeneity in δ.
3. What makes for a *good* monetary policy in a world inhabited by intuitive (dual-processing) agents?
4. Extending the empirical analysis to account for broader data base
5. Could the intuitive model be activated *endogenously* as a response to other events?