Imperfect Macroeconomic Expectations: Evidence and Theory

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State of The Art

Lots of lessons outside representative agent, rational expectations benchmark

But also a “wilderness” of alternatives

- Rational inattention, sticky info, etc. (Sims, Mankiw & Reis, Mackowiak & Wiederholt)
- Higher-order uncertainty (Morris & Shin, Woodford, Nimark, Angeletos & Lian)
- Level-K thinking (Garcia-Schmidt & Woodford, Farhi & Werning, Iovino & Sergeyev)
- Cognitive discounting (Gabaix)
- Over-extrapolation (Gennaioli, Ma & Shleifer, Fuster, Laibson & Mendel, Guo & Wachter)
- Over-confidence (Kohlhas & Broer, Scheinkman & Xiong)
- Representativeness (Bordalo, Gennaioli & Shleifer)
- Undue effect of historical experiences (Malmendier & Nagel)
- ...

This Paper

Contributions:

- Use a parsimonious framework to organize existing evidence and various theories
- Provide new evidence
- Identify the “right” model of expectations for business cycle context

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- Best model: dispersed info + over-extrapolation
- Little support for FIRE, cognitive discounting, level-k thinking

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Outline

Fact 1: Under-reaction in Aggregate Forecasts

Coibion and Gorodnichenko (2015)

$$\left(x_{t+k} - \overline{\mathbb{E}}_t x_{t+k}\right) = a + K_{\text{CG}} \cdot \left(\overline{\mathbb{E}}_t x_{t+k} - \overline{\mathbb{E}}_{t-1} x_{t+k}\right) + u_t$$

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	(1)	(2)	(3)	(4)
variable	Unemployment		Inflation	
sample	1968-2017	1984-2017	1968-2017	1984-2017
Revision$_t$ (K_{CG})	0.741	0.809	1.528	0.292
	(0.232)	(0.305)	(0.418)	(0.191)
R^2	0.111	0.159	0.278	0.016
Observations	191	136	190	135

Notes: The dataset is the Survey of Professional Forecasters and the observation is a quarter between Q4-1968 and Q4-2017. The forecast horizon is 3 quarters. Standard errors are HAC-robust, with a Bartlett ("hat") kernel and lag length equal to 4 quarters. The data used for outcomes are first-release.

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Bad news for: RE + *common* information

Good news for: (i) RE + *dispersed* noisy information

(ii) under-extrapolation, cognitive discounting, level-K

Fact 2: Over-reaction in Individual Forecasts

Bordalo, Gennaioli, Ma, and Shleifer (2018); Kohlhas and Broer (2018); Fuhrer (2018)

$$(x_{t+k} - \mathbb{E}_{i,t}x_{t+k}) = a + K_{\text{BGMS}} \cdot (\mathbb{E}_{i,t}x_{t+k} - \mathbb{E}_{i,t-1}x_{t+k}) + u_t$$

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	(1)	(2)	(3)	(4)
variable	Unemployment		Inflation	
sample	1968-2017	1984-2017	1968-2017	1984-2017
$\text{Revision}_{i,t}$ (K_{BGMS})	0.321	0.398	0.143	-0.263
	(0.107)	(0.149)	(0.123)	(0.054)
R^2	0.028	0.052	0.005	0.025
Observations	5383	3769	5147	3643

Notes: The observation is a forecaster by quarter between Q4-1968 and Q4-2017. The forecast horizon is 3 quarters. Standard errors are clustered two-way by forecaster ID and time period. Both errors and revisions are winsorized over the sample to restrict to 4 times the inter-quartile range away from the median. The data used for outcomes are first-release.

BGMS argue that $K_{\text{BGMS}} < 0$ is more prevalent in other forecasts. If so, then:

Bad news for: under-extrapolation, cognitive discounting, and level-K thinking

Good news for: over-extrapolation and over-confidence (or "representativeness")

Facts 1 + 2 $\Rightarrow$ Dispersed Info

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sample	1968-2017	1984-2017	1968-2017	1984-2017
K_{CG}	0.741	0.809	1.528	0.292
K_{BGMS}	0.321	0.398	0.143	-0.263
$K_{CG} > K_{BGMS}$	✓	✓	✓	✓

Q: What does $K_{CG} > K_{BGMS}$ mean?

A: *My* forecast revision today predicts *your* forecast error tomorrow

Evidence of dispersed private information

combined regression

Fact 3: Over-reaction in Aggregate Forecasts

Kohlhas and Walther (2019)

$$\left(x_{t+k} - \overline{\mathbb{E}}_t x_{t+k}\right) = a + K_{\text{KW}} \cdot x_t + u_t$$

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	(1)	(2)	(3)	(4)
variable	Unemployment		Inflation	
sample	1968-2017	1984-2017	1968-2017	1984-2017
x_t (K_{KW})	-0.061	-0.036	0.111	-0.068
	(0.056)	(0.038)	(0.075)	(0.068)
R^2	0.016	0.007	0.058	0.012
Observations	194	136	193	135

Notes: The dataset is the Survey of Professional Forecasters and the observation is a quarter between Q4-1968 and Q4-2017. The forecast horizon is 3 quarters. Standard errors are HAC-robust, with a Bartlett ("hat") kernel and lag length equal to 4 quarters. The data used for outcomes are first-release.

Bad news for: noisy REE that generates sluggishness and inertia

Good news for: over-extrapolation

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Good news for: over-extrapolation

But: hard to reconcile with Fact 1

Outline

An "Umbrella Theory"

Physical Environment

Noisy signal

$$s_{i,t} = x_t + u_{i,t}/\sqrt{\tau}$$

Process for unemployment or inflation

$$x_t = \rho x_{t-1} + \epsilon_t$$

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Two non-rational Ingredients

Perception of signal

$$s_{i,t} = x_t + u_{i,t}/\sqrt{\hat{\tau}}$$

over- or
under-confidence?

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Perception of signal

$$s_{i,t} = x_t + u_{i,t}/\sqrt{\hat{\tau}}$$

over- or
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Perception of process

$$x_t = \hat{\rho} x_{t-1} + \eta_t$$

over- or
under-extrapolation?

later: $\hat{\rho} < \rho$ in GE $\approx$
cognitive discounting,
level-K thinking

Facts 1-3 in the Model

Proposition. The theoretical counterparts of the regression coefficients are:

$$K_{\mathsf{CG}} = \kappa_1 \hat{\tau}^{-1} - \kappa_2(\hat{\rho} - \rho) \qquad \text{(Fact 1)}$$

$$K_{\mathsf{BGMS}} = -\kappa_3(\hat{\tau} - \tau) - \kappa_4(\hat{\rho} - \rho) \qquad \text{(Fact 2)}$$

$$K_{\mathsf{KW}} = \kappa_5 \hat{\tau}^{-1} - \kappa_6(\hat{\rho} - \rho) \qquad \text{(Fact 3)}$$

for some positive scalars $\kappa_1, \ldots, \kappa_6$ that depend on the deeper parameters.

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Key lessons:

- Moments of *average* forecasts depend on *perceived*, not actual, precision
- Actual level of noise matters only for moments of *individual* forecasts
- Fact 2 conflates over-confidence and over-extrapolation
- Facts 1 and 3 conflate noise and over-extrapolation (in different ways)

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Is there a better way to understand what's going on both in the theory and in the data?

The Missing Piece: Impulse Response Functions

Proposition. Let $\{\zeta_k\}_{k=1}^{\infty}$ be the IRF of the average, one-step-ahead, forecast error.

(i) If $\hat{\rho} < \rho$, then $\zeta_k > 0\ \forall k$.

(ii) If $\hat{\rho} > \rho$ and $\hat{\tau}$ large enough relative to $\hat{\rho} - \rho$, then $\zeta_k < 0\ \forall k$

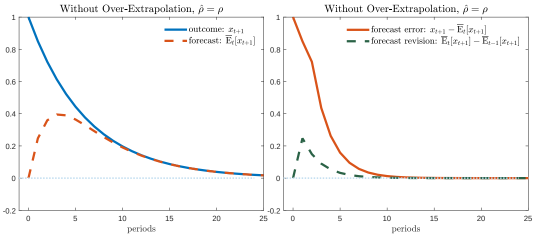
(iii) If $\hat{\rho} > \rho$ and $\hat{\tau}$ small enough relative to $\hat{\rho} - \rho$, then $\zeta_k > 0\ \forall k < k_{\text{IRF}}$ and $\zeta_k < 0$ for $\forall k > k_{\text{IRF}}$, for some $k_{\text{IRF}} \in (1, \infty)$.

That is, average forecasts under-react early and overshoot later if and only if there is both over-extrapolation and sufficiently slow learning

Key idea:

- When shock hits: everything is noisy, forecasts under-react
- Many quarters after shock: noise is gone, tendency to over-extrapolate takes over

Visualizing the Theoretical Prediction



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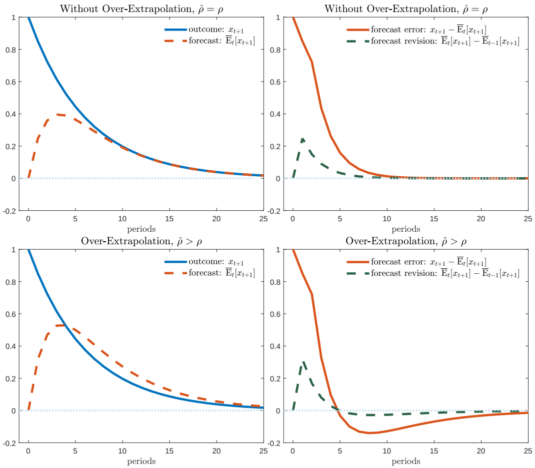

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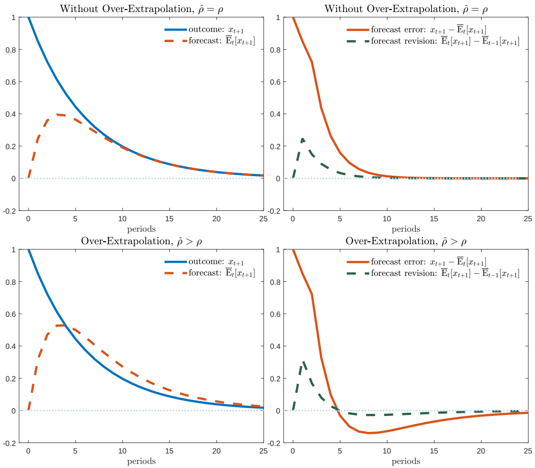

Bonus: regression coefficients deconstructed

$K_{CG} \sim Cov(errors, revisions) \sim IRF_{errors} \times IRF_{revisions}$

$K_{KW} \sim Cov(errors, outcome) \sim IRF_{errors} \times IRF_{outcome}$

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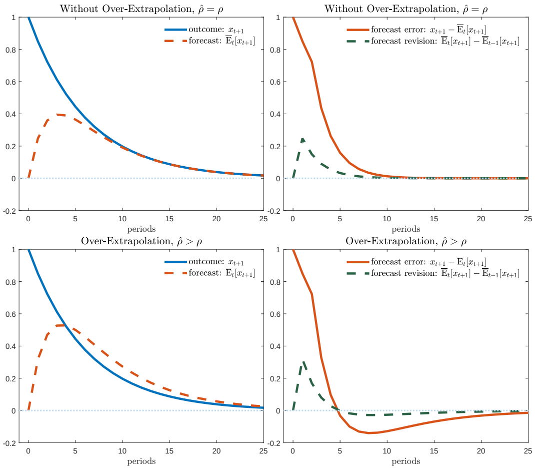

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Facts 1 and 3 ($K_{CG} > 0$ and $K_{KW} < 0$) consistent with noise and over-extrapolation

and so is Fact 2 ($K_{BGMS} < 0$)

Outline

Estimation Strategy

Shocks: usual suspects (e.g., Gali tech); or DSGE shocks (e.g., JPT inv); or "main business cycle shocks" (Angeletos, Collard & Dellas, 2020)

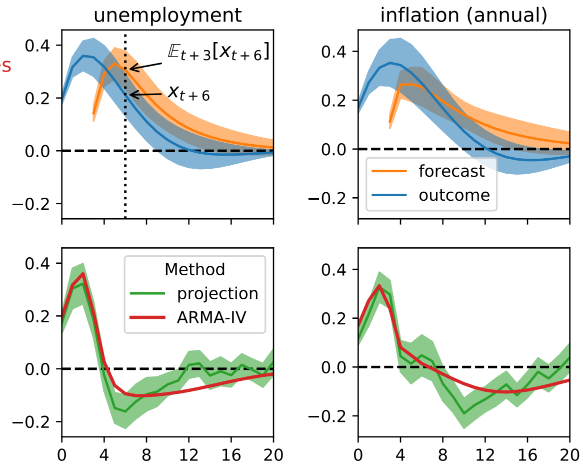
Estimation method: plain-vanilla linear projection;
or big VARs; or ARMA-IV (novel approach) details

Moments of interest:

$$\left(\frac{\partial \text{ForecastError}_{t+k}}{\partial \text{BusinessCycleShock}_t} \right)_{k=0}^{K} = \text{Pattern of mistakes}$$

Fact 4: Delayed Over-Shooting in Response to Main BC Shocks

Each "slice" compares 3-Q-ahead forecasts with outcome



forecast and outcome

forecast error

Shaded area = ± 1 SE

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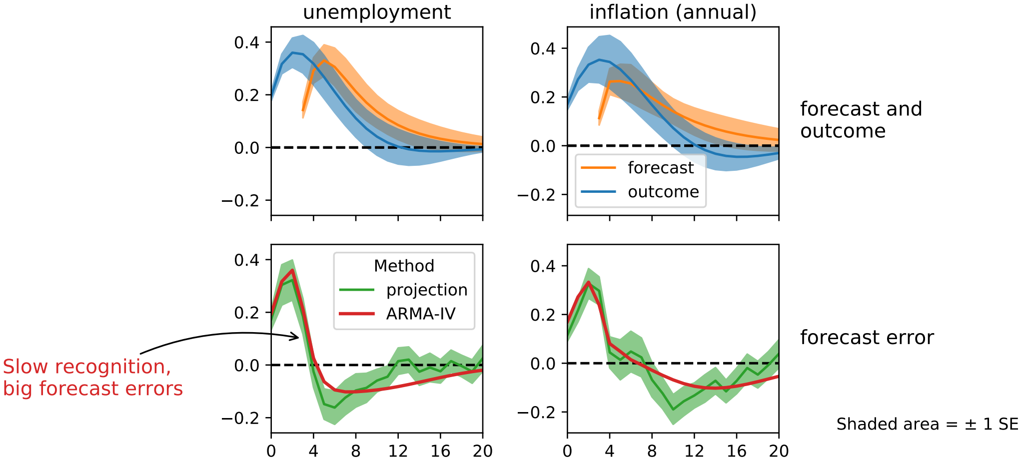

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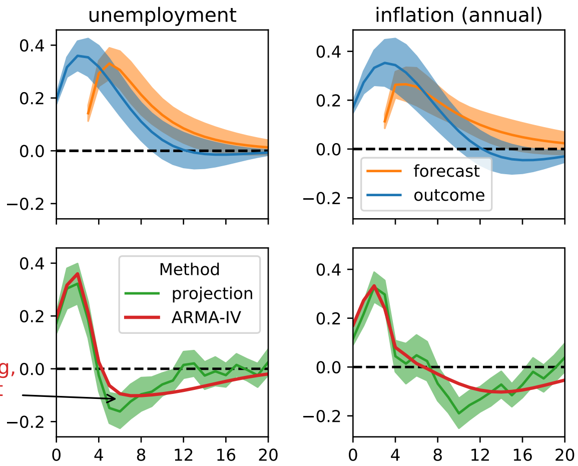


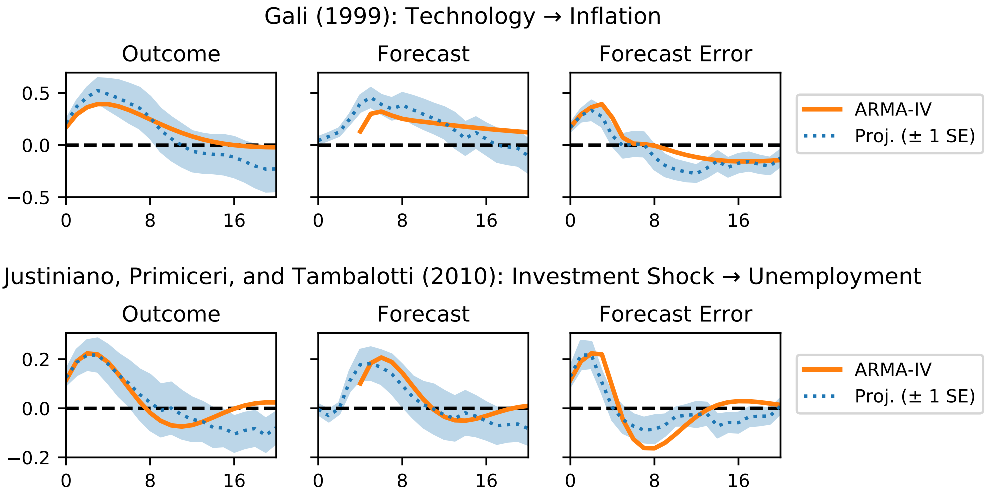
forecast and outcome

forecast error

Delayed over-shooting, smaller but persistent forecast errors

Shaded area = ± 1 SE

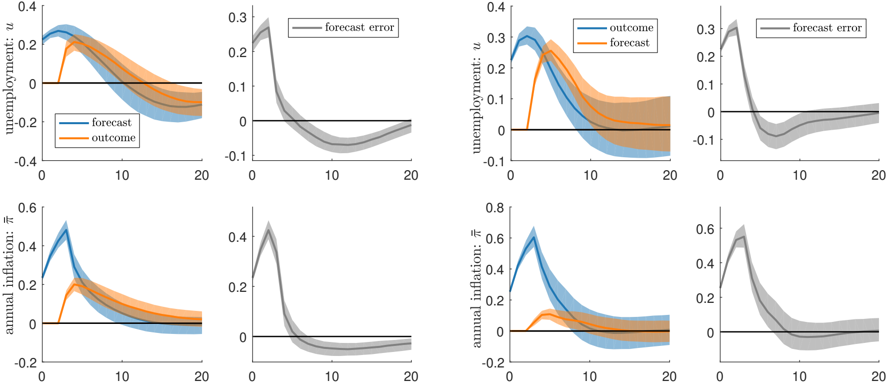
Fact 4: Same Pattern with Other Identified Shocks



Fact 4: Same Pattern in Structural VARs

13-Variable Model: macro "usual suspects" + unemployment and inflation forecasts (SPF) list

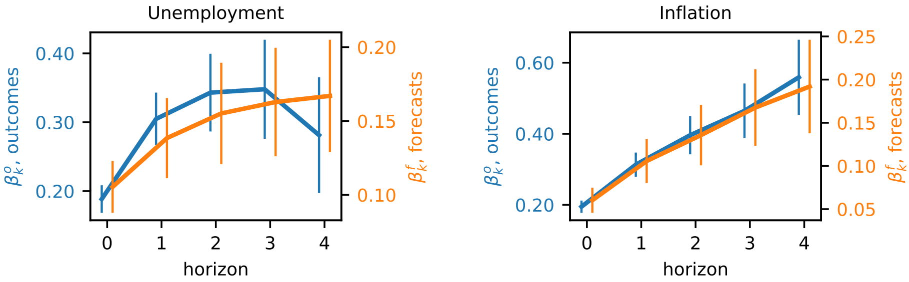
ACD, 2020 (max-share for BC) Cholesky (one-step-ahead Error)



Corroborating Evidence: Over-extrapolation in the "Term Structure"

$$\bar{\mathbb{E}}_t[x_{t+k}] = \alpha_k + \beta_k^f \cdot \epsilon_t + \gamma' W_t + u_{t+k}$$ Expectation from $t = 0$

$$x_{t+k} = \alpha_k + \beta_k^o \cdot \epsilon_t + \gamma' W_t + u_{t+k}$$ Reality from $t = 0$



Outline

Need to Combine Frictions to Explain Facts

	Models	Facts 1	2	3	4
Information	Noisy common information	No	No*	Yes	No
	Noisy dispersed information	Yes	No*	Yes	Yes
Confidence	Over-confidence or representativeness heuristic	No	Maybe	No	No
	Under-confidence or "timidness"	No	Maybe	No	No
Foresight	Over-extrapolation	No	Maybe	Yes	Yes
	Under-extrapolation or cognitive discounting or level-K	Yes	Maybe	No	No

Need to Combine Frictions to Explain Facts: A Winning Combination

	Models	Facts			
		1	2	3	4
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Outline

Tractable NK Model with Imperfect Expectations

Familiar Ingredients

Euler equation/DIS

$$c_t = \mathbb{E}_t^*[c_{t+1}] - \varsigma r_t + \epsilon_t$$

Market clearing

$$c_t = y_t$$

Demand shock

$$\xi_t \equiv -\varsigma r_t + \epsilon_t = \rho \xi_t + \epsilon_t$$

Prices fully rigid (relax later on)

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$$s_{i,t} = \xi_t + u_{i,t}/\sqrt{\tau}$$

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Perception of signal

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over- or under-confidence?

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over- or under-extrapolation?

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over- or under-extrapolation?

$\hat{\rho} < \rho$ in GE $\approx$ cognitive discounting, level-K

Transparent Mapping between Data and Theory

Proposition: Mapping to Forecast Data

Closed-form expressions:

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F3. $K_{\text{KW}} = \mathcal{K}_{\text{KW}}(\hat{\tau}, \rho, \hat{\rho}; \text{mpc})$

F4. $\left\{ \frac{\partial \overline{\text{Error}}_{t+k}}{\partial \eta_t} \right\}_{k \geq 1} = F(\hat{\tau}, \rho, \hat{\rho}; \text{mpc})$

Proposition: Equilibrium Outcomes

As-if representative, rational agent with

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myopia and anchoring

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- Key behavior pinned down by $(\hat{\tau}, \rho, \hat{\rho})$
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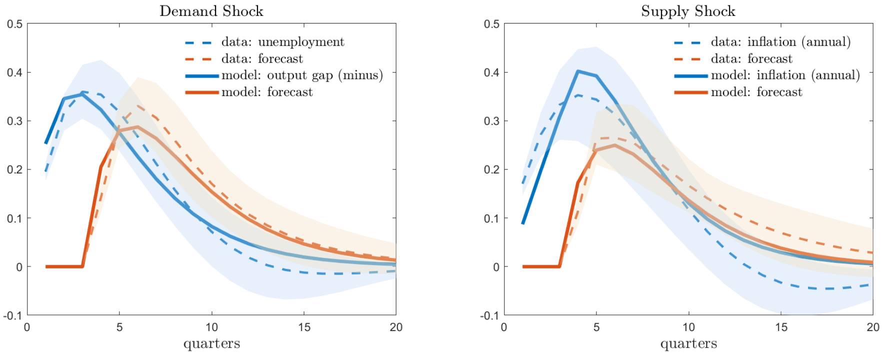
New Keynesian Model Calibrated to Expectations Evidence

Full model: add NKPC (with imperfect expectations) and Taylor rule

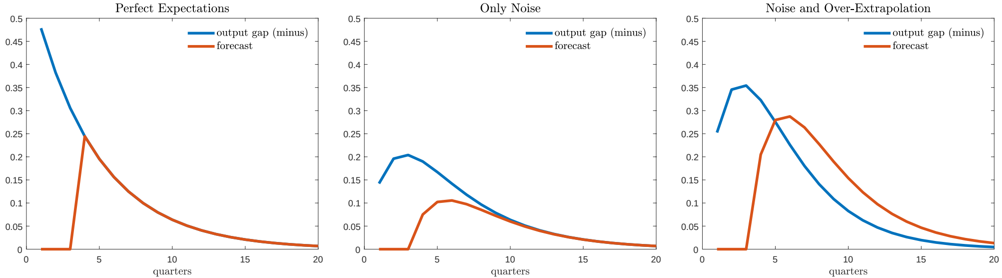


Good fit for demand shock, mediocre for supply shock

Right qualitative ingredients but no abundance of free parameters

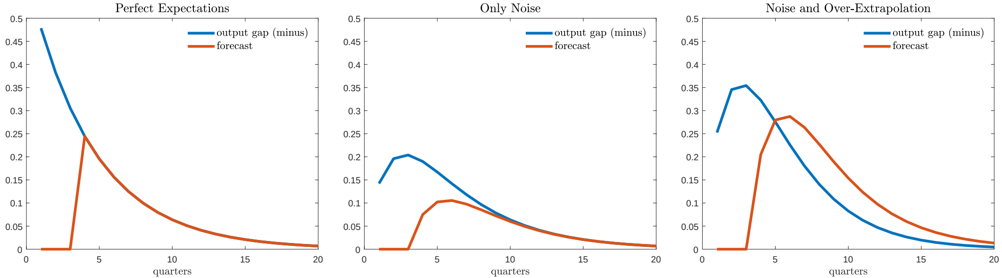
parameter values

Counterfactuals: Interaction of Forces Matters



Counterfactuals: Interaction of Forces Matters

+ noise

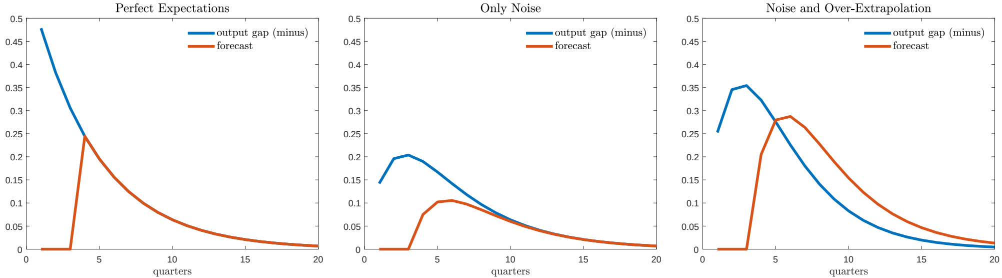


Noise smooths and dampens IRF

("stickiness/inertia and myopia")

Counterfactuals: Interaction of Forces Matters

+ over-extrapolation



Noise smooths and dampens IRF
("stickiness/inertia and myopia")

Over-extrapolation increases present value and amplifies initial response
("amplification and momentum")

Outline

Conclusion

Contributions:

- Developed a simple framework to organize diverse theories and evidence
- Found little support for certain theories (FIRE, cognitive discounting, level-K)
- Argued that the “right” model combines dispersed info and over-extrapolation
- Clarified which moments of forecasts are most relevant in the theory
- Illustrated GE implications

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Limitations/Future Work:

- *Context*: "regular business cycles" vs. crises or specific policy experiments
- *Forecast data*: ideally we would like expectations of firms and consumers, and for the objects that matter the most for their choices

Facts 1 + 2: Showing Under-reaction and Dispersion

$$\text{Error}_{i,t,k} = a - K_{\text{noise}} \cdot (\text{Revision}_{i,t,k} - \text{Revision}_{t,k}) + K_{\text{agg}} \cdot \text{Revision}_{t,k} + u_{i,t,k}$$

	(1)	(2)	(3)	(4)
variable	Unemployment		Inflation	
sample	1968-2017	1984-2017	1968-2017	1984-2017
$\text{Revision}_{i,t}$ - Revision_t ($-K_{noise}$)	-0.166	-0.162	-0.346	-0.410
	(0.043)	(0.053)	(0.042)	(0.041)
Revision_t (K_{agg})	0.745	0.841	1.550	0.412
	(0.173)	(0.210)	(0.278)	(0.180)
R^2	0.103	0.152	0.211	0.072
Observations	5383	3769	5147	3643

Notes: The observation is a forecaster by quarter between Q4-1968 and Q4-2017. The forecast horizon is 3 quarters. Standard errors are clustered two-way by forecaster ID and time period. Both errors and revisions are winsorized over the sample to restrict to 4 times the inter-quartile range away from the median. The data used for outcomes are first-release.

back

Estimation Strategy

Overall goal: allow flexibility for dynamics to be "shock-specific"

ARMA-IV: two-stage-least-squares estimate of

$$x_t = \alpha + \sum_{p=1}^{P} \gamma_p \cdot x_{t-p}^{\mathrm{IV}} + \sum_{k=1}^{K} \beta_k \cdot \epsilon_{t-k} + u_t$$

$$X_{t-1} = \eta + \mathcal{E}_{t-1}' \Theta + e_t$$

where $X_{t-1} \equiv (x_{t-p})_{p=1}^{P}$, $\mathcal{E}_{t-1} \equiv (\epsilon_{t-K-j})_{j=1}^{J}$ and $J \geq P$. Main specification: $P = 3$, $J = 6$.

Projection: OLS estimation at each horizon h of

$$x_{t+h} = \alpha_h + \beta_h \cdot \epsilon_t + \gamma' W_t + u_{t+h}$$

where the controls W_t are x_{t-1} and $\bar{\mathbb{E}}_{t-k-1}[x_{t-1}]$.

Estimation Strategy

Back

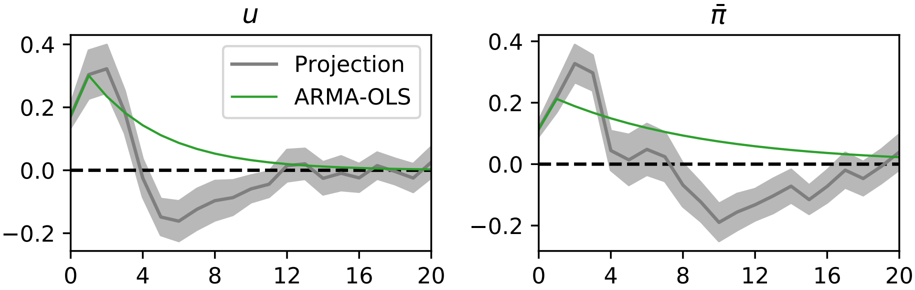

Figure 1: *

Forecast error estimation with projection method (grey) and ARMA-OLS(1,1) (green).

Example Back

Variable List for SVAR

10 usual suspects: real GDP, real investment, real consumption, labor hours, the labor share, the Federal Funds Rate, labor productivity, and utilization-adjusted TFP

3 forecast variables: three-period-ahead unemployment forecast, three-period annual inflation forecast, one-period-ahead quarter-to-quarter inflation forecast

Back

The Role of Noise and HOB

As-if Representation (builds on Angeletos & Huo, 2018):

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- $\omega_f < 1$: captures noise plus myopia due to HOB (Angeletos & Lian, 2018)
  $\rightsquigarrow$ resolution to forward guidance puzzle etc
- $\omega_b > 0$: captures learning, or momentum in beliefs
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- both distortions disciplined by moments of average forecasts (CG or ours)
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The Right Combination

As-if Representation (builds on Angeletos & Huo, 2018):

$$c_t = -r_t + \omega_f \mathbb{E}^*_t[c_{t+1}] + \omega_b c_{t-1}$$

Over-extrapolation plus enough noise $\Rightarrow$ $\omega_f < 1 \quad \omega_b > 0$

- matches all facts about expectations
- quantitative bite disciplined by our evidence

back

Model Parameters

Table 1: Exogenously Set Parameters

Parameter	Description	Value
θ	Calvo prob	0.6
κ	Slope of NKPC	0.02
χ	Discount factor	0.99
mpc	MPC	0.3
ς	IES	1.0
ϕ	Monetary policy	1.5

Table 2: Calibrated Parameters

	$\hat{\rho}$	ρ	τ
Demand shock	0.94	0.80	0.38
Supply shock	0.82	0.57	0.15

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