The NY Fed DGSE Model: A Post COVID Assessment of its Performance

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Disclaimer: The views expressed here do not necessarily reflect those of the Federal Reserve Bank of New York or the Federal Reserve System. **The NY Fed DSGE forecast is *not* an official New York Fed forecast, but only an input to the Research staff's overall forecasting process.**

Are DSGEs of any use to central banks?

ECONOMICS

Economics Struggles to Cope With Reality

174 JUNE 10, 2016 8:00 AM EDT

By Noah Smith

"... most people outside the discipline who take one look at these models [DSGEs] immediately think they're kind of a joke. They contain so many unrealistic assumptions that they probably have little chance of capturing reality. Their forecasting performance is abysmal. Some of their core elements are clearly broken. Any rigorous statistical tests tend to reject these models instantly, because they always include a hefty dose of fantasy."

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Link to abysmal: Abstract of Gürkaynak, Kisacikoglu, Rossi (Advances in Econometrics, 2013): "... there is no single best forecasting method. For example, typically simple AR models are most accurate at short horizons and *DSGE models are most accurate at long horizons* ... "

Outline

- The NY Fed DSGE is ... a DSGE model! How did it actually fare in forecasting over the (rather turbulent) past 10+ years? How did it address the challenges it faced? How did it rationalize all that happened to the economy?

1. NY Fed DSGE model
2. Estimation methods — making (repeated) estimation feasible
3. The NY Fed DSGE's forecasting performance
4. COVID and its aftermath
5. Inflation and disinflation policies

NY Fed DSGE

- The NY Fed DSGE model was a simple three-equations NK DSGE from 2004 to 2008, and was not used for forecasting. In 2008 we began to build a medium-size DSGE with financial frictions, which has been routinely used for forecasting since late 2010

- While the model evolved over time, the NY Fed DSGE currently is a medium/largish-scale model following Smets and Wouters, 2007 *with financial frictions* as in Bernanke, Gertler, and Gilchrist, 1999/Christiano, Motto, and Rostagno, 2014
  - Model is **estimated** using the following observables (1960Q1-...): the growth rate of real output (*both GDP and GDI*), consumption, investment, real wage, hours worked, inflation (*both core PCE and GDP deflator*), *long run inflation expectations*, the FFR, *the ten-year Treasury yield*, *Fernald's TFP growth*, *Baa spreads*

- Model's code is available on GitHub
  - Externality (hopefully!) for other policy institutions. Model *validation* done by the outside world.

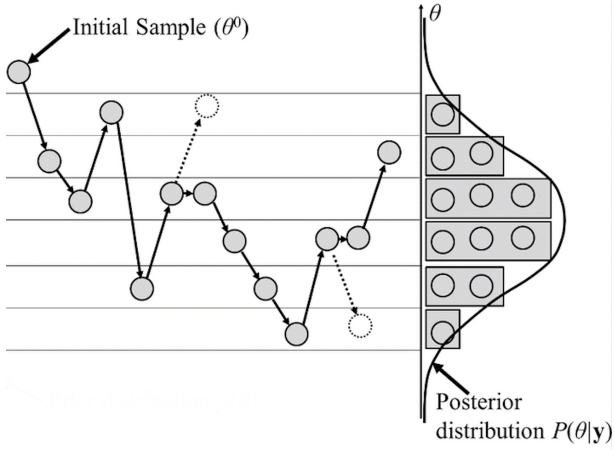
- Since 2014, each quarter we publish the DSGE forecasts in the NY Fed Liberty Blog
  - We do not forecast because the DSGE is "good" at forecasting — **we forecast with the DSGE to test the model**

Making (repeated) estimation feasible

- The posterior $p(\theta|y_{1:T})$ does not have a known form $\rightarrow$ Monte Carlo methods
- Standard approach to obtaining draws from the *posterior distribution* in DSGE estimation: *Markov Chain* Monte Carlo (Random Walk Metropolis Hastings; e.g., Dynare)

- Start with <u>one</u> particle θ and let it travel the posterior distribution (always accept moves "up" and only sometimes accept moves "down")

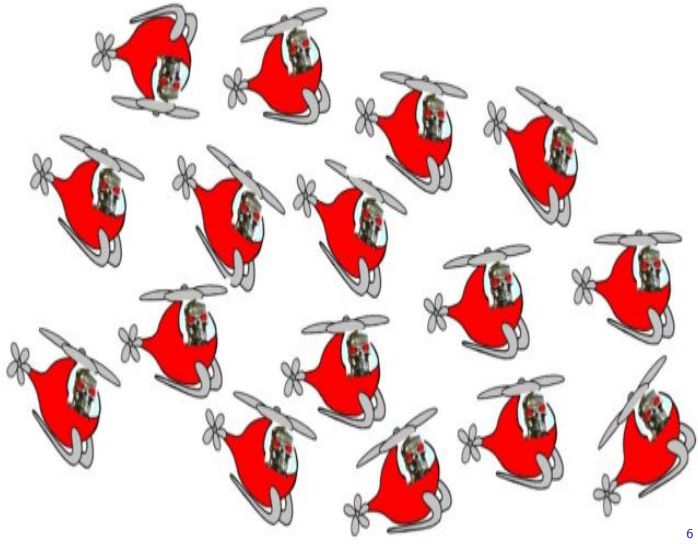
- Problem: *It is difficult to parallelize* (it's Markov!)
  ... and it can get stuck!



Different approach: Sequential Monte Carlo

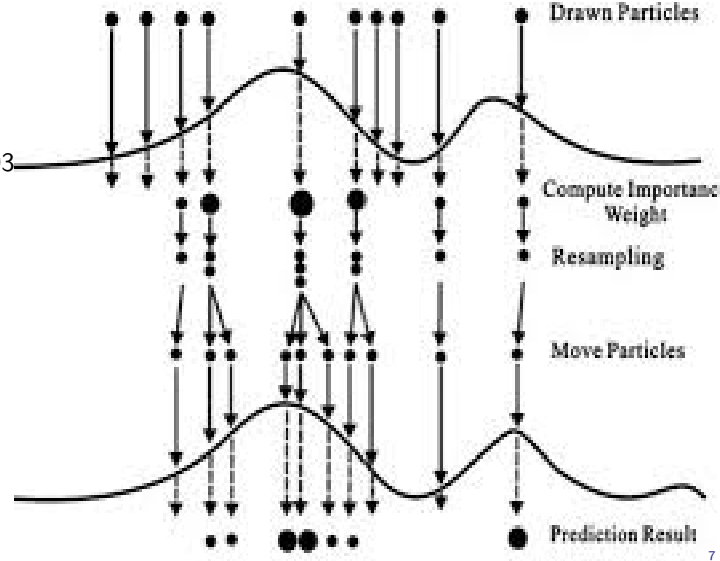
- Relatively "new" to the DSGE estimation literature (Creal, 2007; Herbst and Schorfheide, 2014, 2015); old for the statistics literature (Gordon et al., 1993; Chopin, 2002, ...)

- Start with a swarm of particles



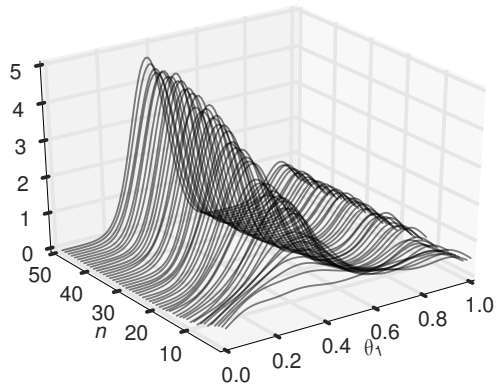
"New" approach: Sequential Monte Carlo

- "New" to the DSGE estimation literature (Creal, 2007, Herbst and Schorfheide, 2014, 2015); old for the statistics literature (Gordon et al., 1993 Chopin, 2002, ...)
- Start with a swarm of particles
- ... and let them all travel and "adapt" to the posterior



SMC in a nutshell

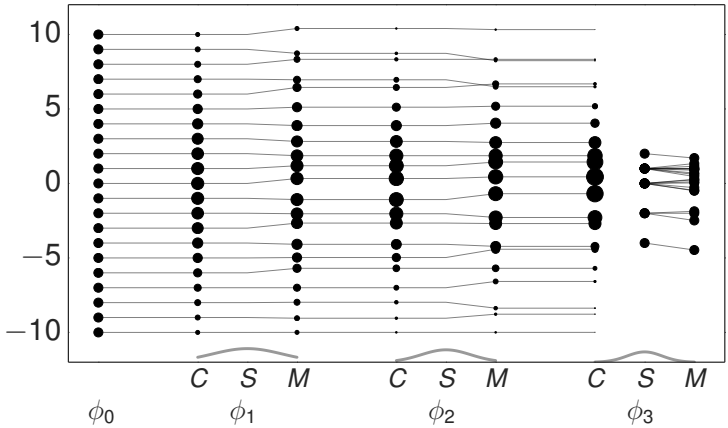
- *Sequential* / "incremental" importance sampling using *likelihood tempering*
- Importance sampling: get a bunch of draws $\{\theta^i\}_{i=1}^N$ from a proposal distribution $q(\theta)$ and compute the associated weights $W_n^i \propto \pi(\theta^i)/q(\theta^i)$
- Problem: effective sample size $ESS = N/\left(\frac{1}{N}\sum_{i=1}^N (W_n^i)^2\right) << N$ if the proposal is "bad"



$$\pi_n(\theta) \propto p(y_{1:T}|\theta)^{\phi_n} p(\theta)$$

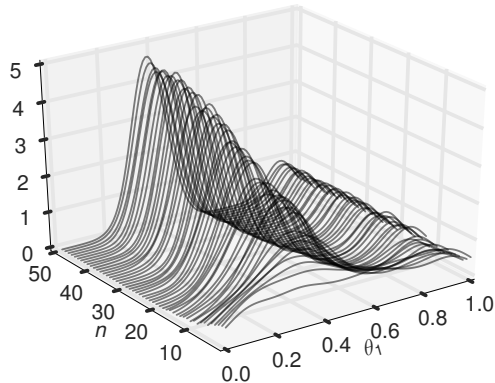
$$\phi_n = 0 \rightarrow 1$$

SMC: A graphical illustration



- $\pi_n(\theta)$ is represented by a swarm of particles $\{\theta_n^i, W_n^i\}_{i=1}^N$
- C is Correction; S is Selection; and M is Mutation.

How fast does $\phi_n \to 1$?

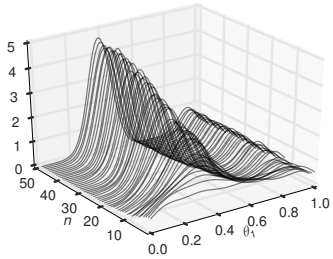


$$\pi_n(\theta) \propto p(y_{1:T}|\theta)^{\phi_n} p(\theta)$$

$$\phi_n = 0 \to 1$$

- If ϕ_n increases rapidly, ESS deteriorates quickly
- Fixed schedule (Herbst and Schorfheide, 2014): $\phi_n = \left(\frac{n}{N_\phi}\right)^\lambda$, $\lambda \sim 2$

Adaptive likelihood tempering



$$\pi_n(\theta) \propto p(y_{1:T}|\theta)^{\phi_n} p(\theta)$$

$$\phi_n = 0 \rightarrow 1$$

- Choose ϕ_n to target a desired level of ESS decrease:

$$f(\phi_n) = \widehat{ESS}(\phi_n) - \alpha \widehat{ESS}_{n-1} = 0$$

- See also Jasra et al., 2011, Del Moral et al., 2012, Schafer and Chopin, 2013, Geweke and Frischknecht, 2014, and Zhou et al., 2015

Generalized tempering/Online estimation

- The initial proposal distribution does not have to be the prior!
- **It can be some other** distribution, e.g., some other **posterior**: $\tilde{p}(\tilde{Y}|\theta)p(\theta)$

$$\pi_n(\theta) \propto p(y_{1:T}|\theta)^{\phi_n}\tilde{p}(\tilde{Y}|\theta)^{1-\phi_n}p(\theta)$$

- If it is the posterior from a shorter sample: e.g., $\tilde{p}(\tilde{Y}|\theta) = p(y_{1:T_0}|\theta),\ T_0 < T \rightarrow$ *data* tempering (but smoother!)
  - Very useful for forecasting, as **you do not have to start from scratch**
  - ... and the *adaptive* tempering (unlike in standard data tempering) assures that the particles survive
- But it can be something else entirely, e.g., estimation obtained using a slightly different model, a different prior, a coarser solution method ...

Summing up on online estimation of the model

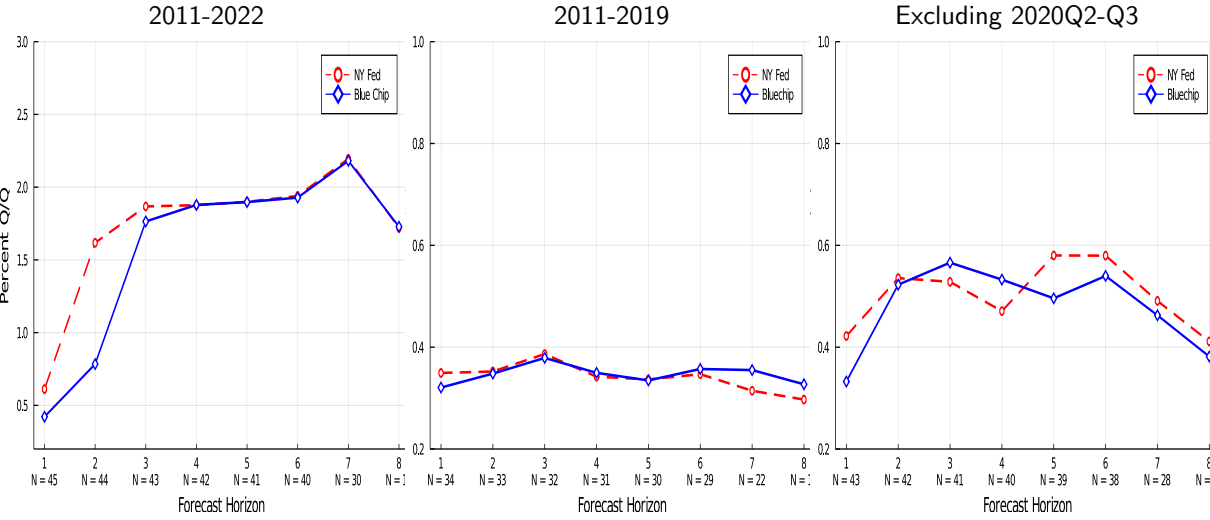
- Reasons to use SMC for models whose likelihood is costly to evaluate
  1. *It can be parallelized*
  2. *Robust* to multimodality
  3. *Previous estimations* (swarm of particles) *can be re-used* as a bridge for new estimations ("online" estimation)
     - new data $\rightarrow$ **routine estimation** (and forecasting evaluation exercises) becomes feasible

- "Online estimation of DSGE models" Cai, Del Negro, Herbst, Matlin, Sarfati, Schorfheide, 2019; see also our blog and our Julia SMC package on GitHub

How Did the NY Fed DSGE Models Fare in Terms of Forecasting?

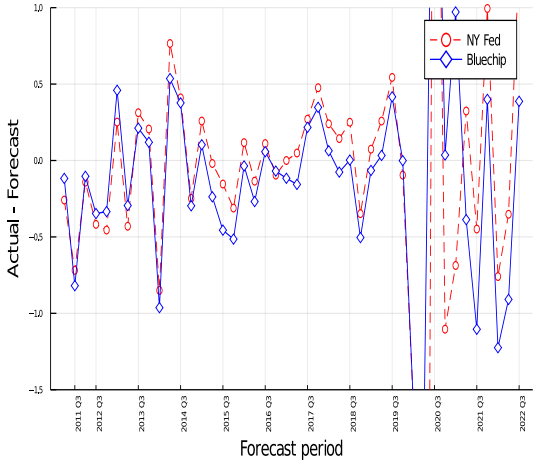
- **Real ~~pseudo~~ real time forecasts**: *Actual forecasts* produced and documented regularly as past of the policy process.
  - Forecasts also published on the NY Fed Liberty Street Blog. Since June 2011, the NY Fed DSGE forecasts have been part of a memo produced four times a year for the FOMC. You can find the NY Fed DSGE forecasts with a 5 year lag on `https://www.federalreserve.gov/monetarypolicy/fomc-memos.htm`
- We document the real real time forecasting performance of the NY Fed DSGE model from 2011 to 2016 in Cai et al., DSGE forecasts of the lost recovery, International Journal of Forecasting 2019
- In this presentation we provide an update with 6 more years of data

RMSEs for GDP growth; DSGE vs Blue Chip Consensus

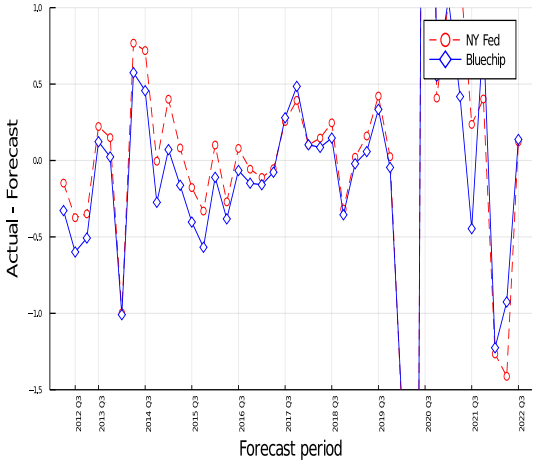


Forecast errors for GDP growth: DSGE vs Blue Chip Consensus

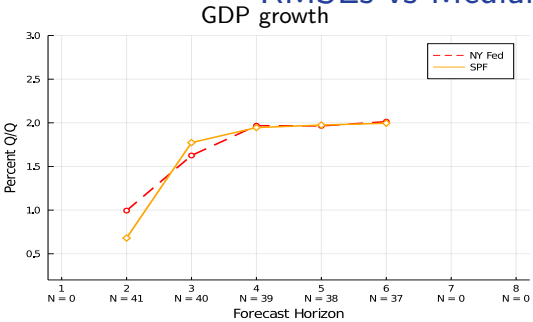
2 quarters ahead

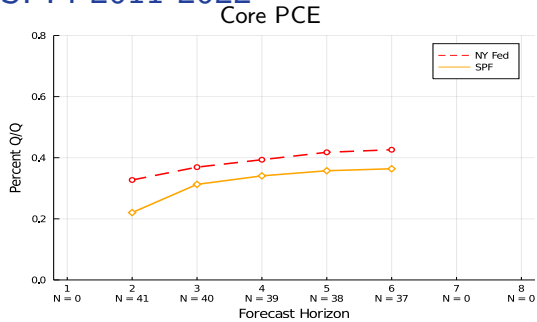


6 quarters ahead

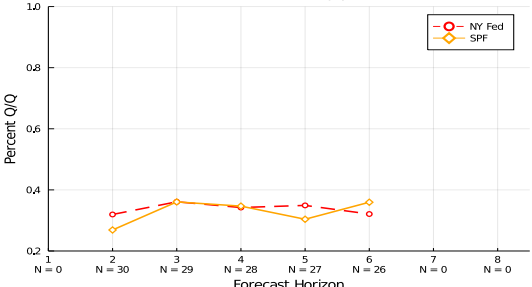


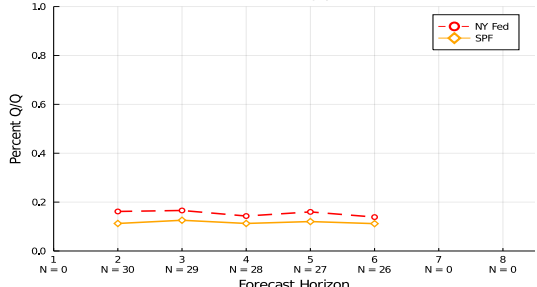
RMSEs vs Median SPF: 2011-2022





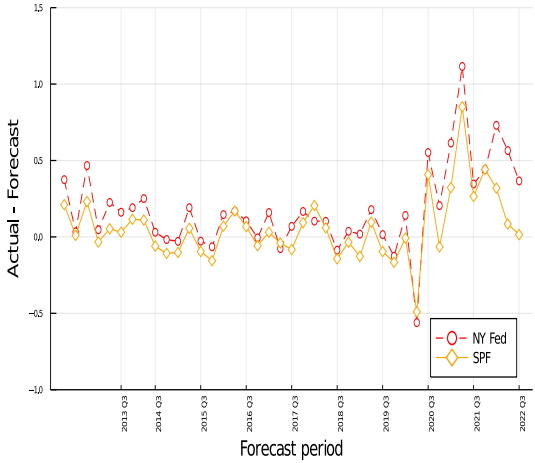
2011-2019



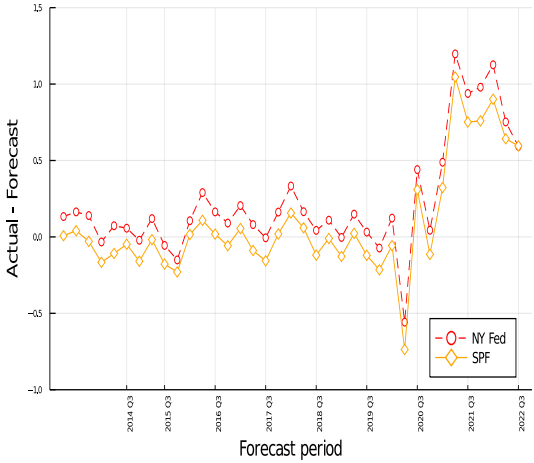


Forecast errors for core PCE inflation: DSGE vs Median SPF

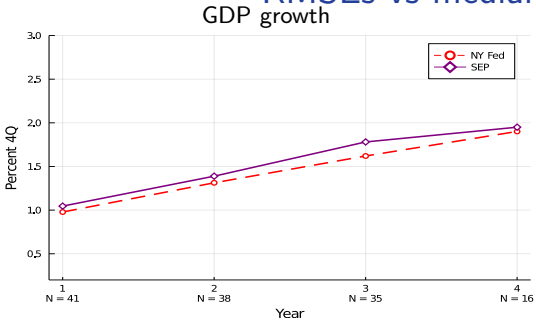
2 quarters ahead

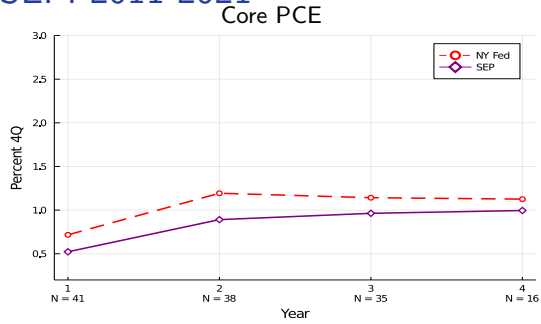


6 quarters ahead

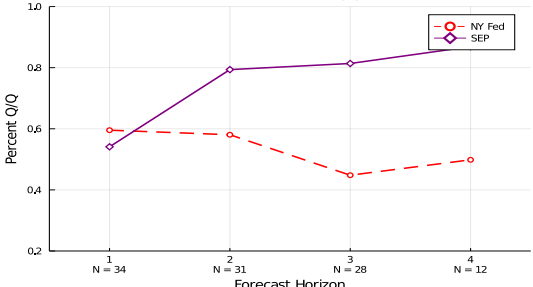


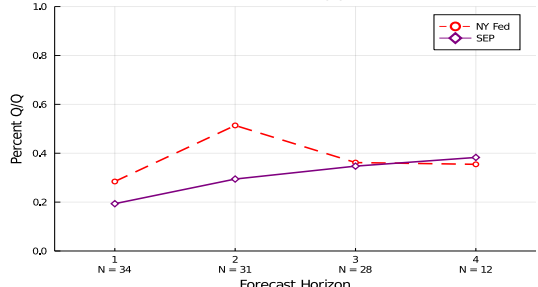
RMSEs vs median SEP: 2011-2021





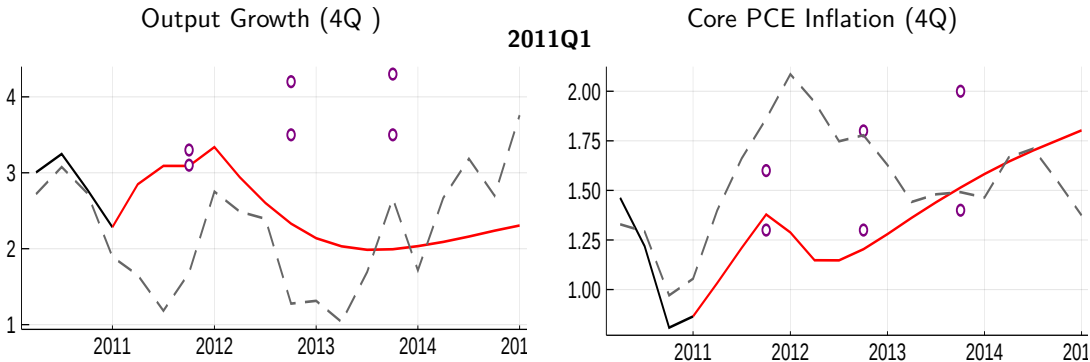
2011-2019





DSGE forecasts of the "lost" recovery

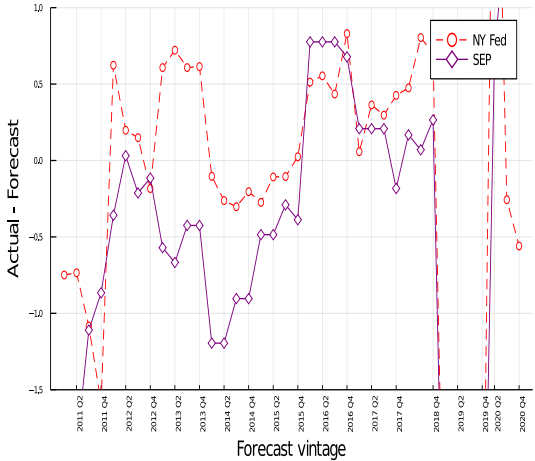
- This was a a challenging period: 1) Deep recession/ *large and persistent output gaps* (*"lost recovery"*); 2) not associated with negative inflation ("*missing deflation*"); 3) FFR stuck at the *ZLB* + *Unconventional monetary policies*



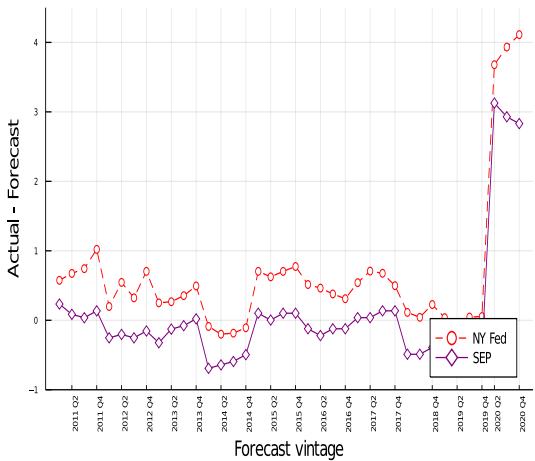
- Unlike the SEP participants, the model projects a slow recovery from the financial crisis (Reinhard and Rogoff, 2009), because in the model the recovery from financial shocks is sluggish

Forecast errors: DSGE vs median SEP

GDP growth next year



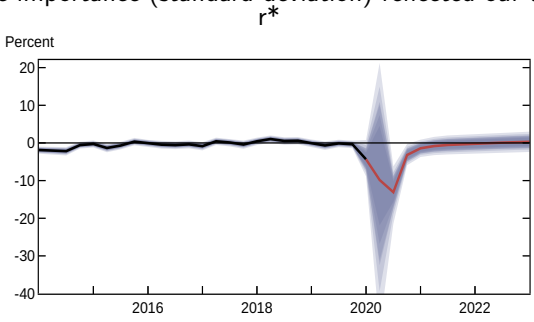
core PCE inflation next year



Modeling the pandemic–COVID shocks

- In response to the pandemic, the DSGE model was changed to accommodate the fact that the economic disruptions caused by COVID-19 are likely different from patterns seen in standard business cycles

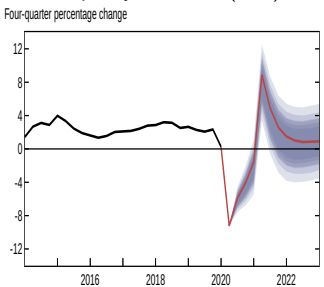
→ **new shocks** designed to reflect lockdowns and social distancing were added (see the model description on GitHub for more details): **temporary** discount rate, productivity, and labor preference shocks (some of which were anticipated to reflect expectations of future lockdowns), whose importance (standard deviation) reflected our *a priori* uncertainty



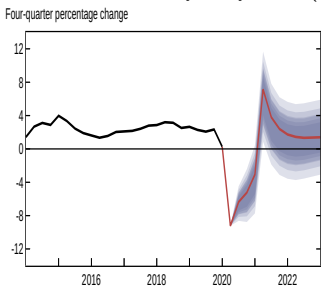
Modeling the pandemic–scenarios

- To incorporate the substantial **uncertainty** surrounding the **persistence** of the economic effects of the pandemic, we constructed three scenarios.
- The forecast combines these scenarios by weighting them according to our a priori views (informed by the SPF probabilistic distribution) on how likely each scenario is (see June 2020 blog post).

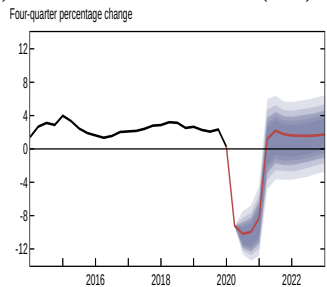
Temporary Lockdown (65%)



Lockdown with Business Cycle Dynamics (10%)

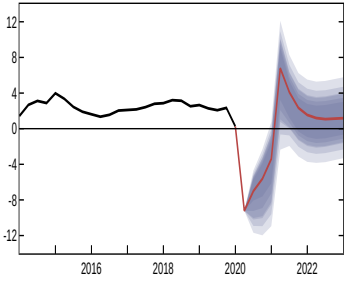


Persistent Demand Shortfall (25%)

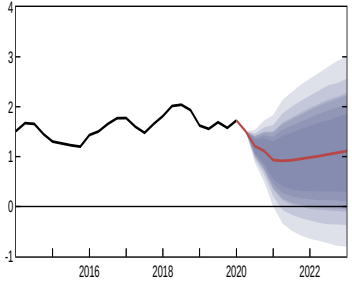


June 2020 forecasts

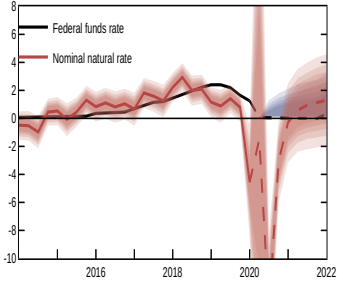
GDP growth

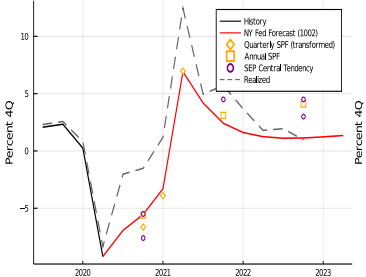


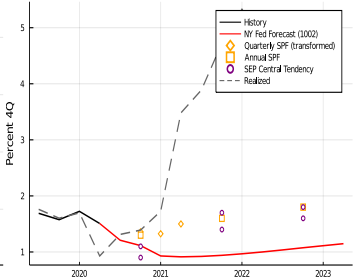
Core PCE inflation



FFR and nominal r*







Introducing Flexible AIT

- Starting in 2020Q4 we replaced the historical (estimated) policy reaction function with a new reaction function, **flexible average inflation targeting (AIT)**, reflecting our interpretation of the changes in the FOMC monetary policy strategy:

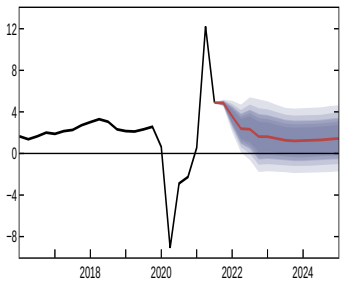
$$R_t = \rho_R R_{t-1} + (1-\rho_R)(1-\rho_p)\varphi_p pgap_t + (1-\rho_R)(1-\rho_y)\varphi_y ygap_t,$$

  where $pgap_t = (\pi_t - 2) + \rho_p pgap_{t-1}$, $ygap_t = (\Delta y_t + z_t - \gamma) + \rho_y ygap_{t-1}$ (ten-quarters half life), and reaction function parameters were chosen so that the liftoff of interest rates from the effective lower bound would take place in early 2023 (in line with FOMC communication then)

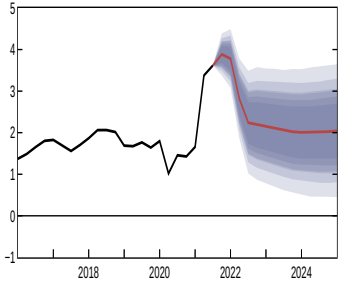
- We also assumed that the introduction of the new reaction function was only **gradually incorporated by the agents in forming expectations**: expectations are formed using a convex combination of forecasts obtained under the old and the new policy reaction functions (see the December 2020 blog post)

December 2021 forecasts

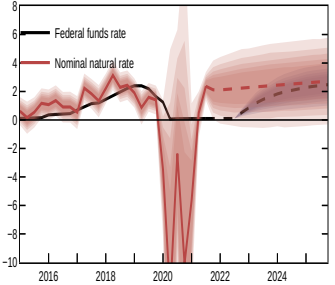
GDP growth

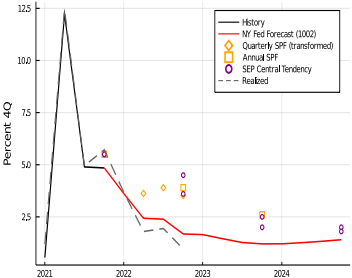


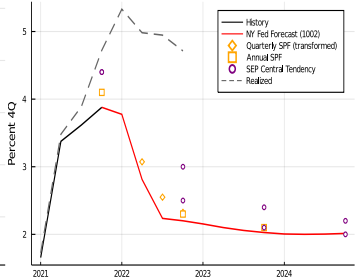
Core PCE inflation



FFR and nominal r*

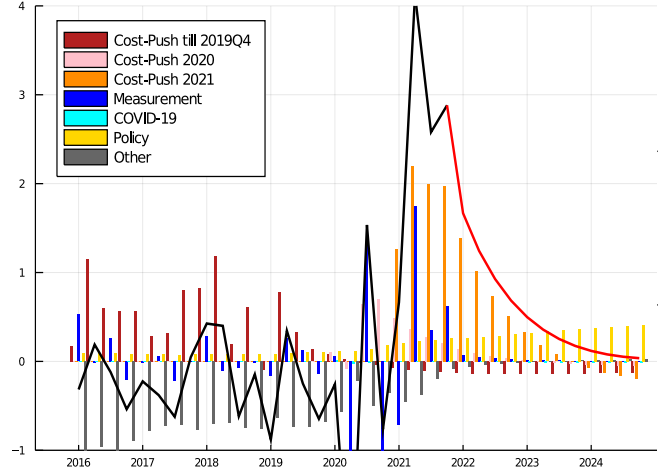




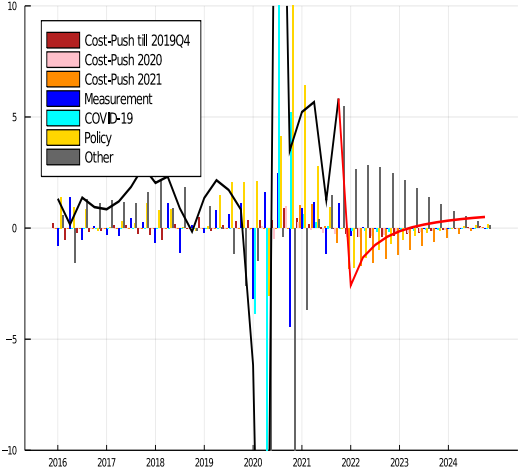


Whatever happened to inflation? (according to the model)

core PCE inflation

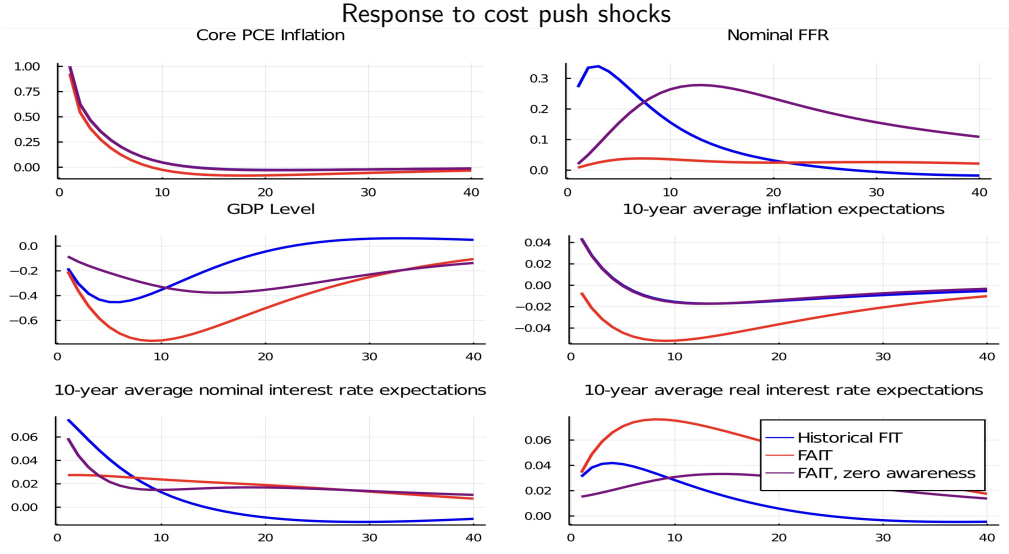


GDP growth



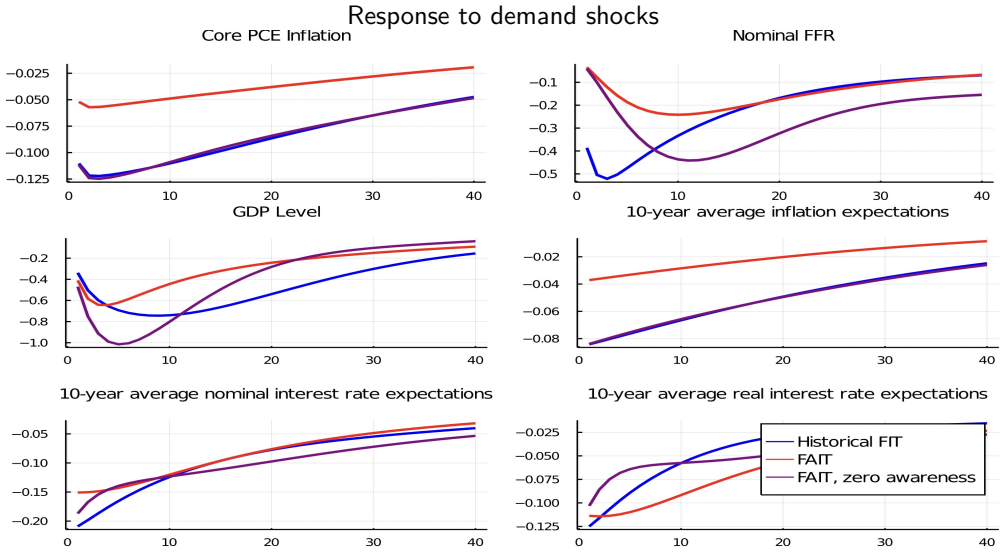
See Liberty St Blog post on Drivers of Inflation: The New York Fed DSGE Model's Perspective

Disinflation policies (according to the model)



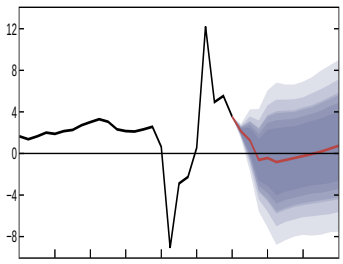
See Liberty St Blog post on Disinflation Policies with a Flat Phillips Curve

Disinflation policies (according to the model)

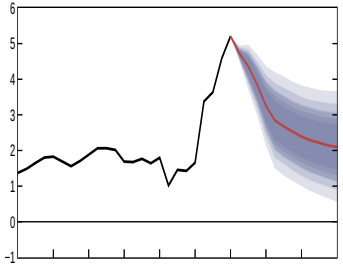


Disinflation policies "in action"–June 2022 forecasts

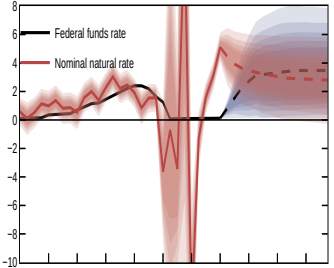
GDP growth

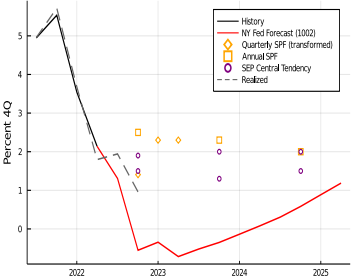


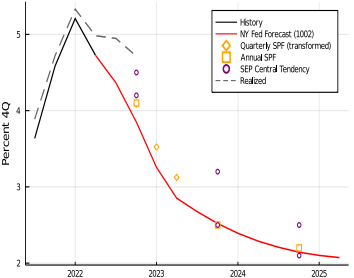
Core PCE inflation



FFR and nominal r*

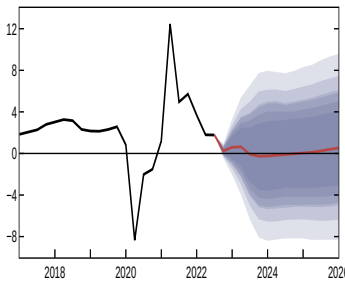




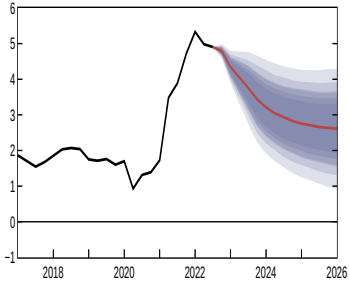


How did it pan out? December 2022 forecasts

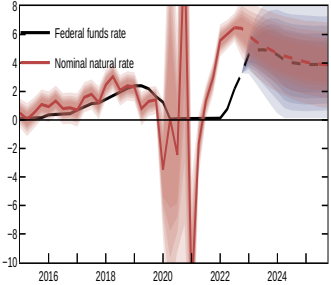
GDP growth

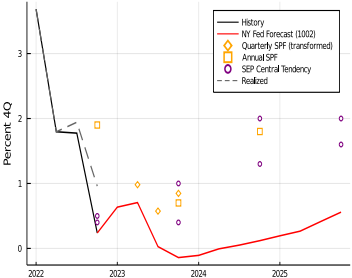


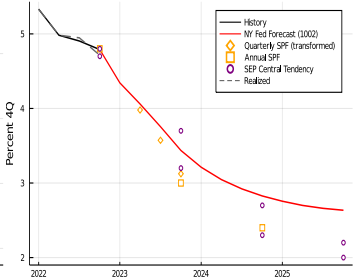
Core PCE inflation



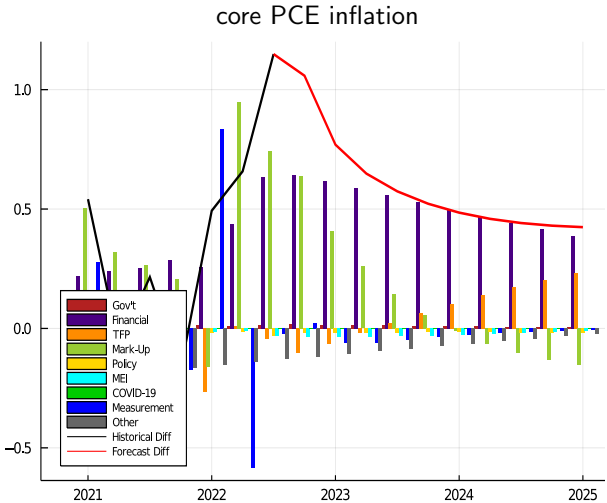
FFR and nominal r*

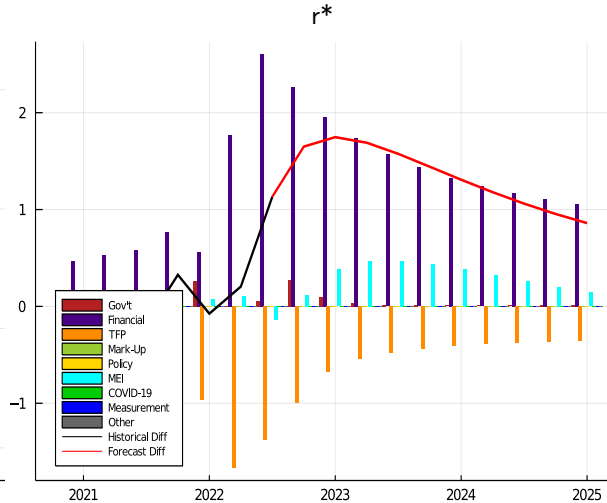






... and why (according to the model)





Conclusions

- We discussed the forecasting performance of the NY Fed DSGE model over the (rather turbulent) past 10+ years; how it addressed the challenges it faced; and how it rationalized all that happened to the economy

- The **real** real time forecasting performance of the NY Fed DSGE model was comparable to that of the Consensus Blue Chip, Median SPF, and SEP for output
  - Perhaps not bad for a model with "so many unrealistic assumptions"

- For inflation this performance was a bit worse than "competitors", although the model had its successes on that front as well (rationalizing the missing disinflation/persistent low inflation after the Great Recession)
  - How can we improve it?