‘The Empirical Implications of the Interest-Rate Lower Bound’ Gust, Lopez-Salido and Smith

Discussion
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The Great Recession and the Zero Lower Bound

- Very ambitious paper that addresses important substantive questions.

- What shocks pushed the U.S. economy into the Great Recession and kept us there?

- How important, quantitatively, was the ZLB constraint on monetary policy during the Great Recession?

Key contribution of the paper

- Gust et. al. estimate parameters of a nonlinear New-Keynesian DSGE model.
  - Data on inflation, output and the funds rate from 1983 to 2011.
  - Bayesian methods.

- First paper to estimate fully nonlinear New-Keynesian DSGE model featuring ZLB as endogenously binding constraint.

Methodological innovation

- Solve model using projection methods.
- Use surrogate transitions in selecting time consuming particle filter evaluations of the likelihood function
  - Exploit easy-to-compute likelihood functions to pre-screen proposed parameter configurations using first-stage acceptance criterion.
- Impressive technically and a very useful methodoligical contribution.

Organization of discussion

- Solution algorithm is still subject to curse of dimensionality, so they have to use a *very* simple model.
- Should we trust their inferences about the sources of the Great Recession and the quantitative impact of the ZLB?
- The multiple equilibrium problem.
- Short-run trade-offs: what kinds of errors do we want to commit?

The Shocks

- Household discount factor

$$\delta_t = \frac{\beta^t}{\Pi_{s=0}^t \eta_s}$$

$$\frac{\delta_{t+1}}{\delta_t} = \frac{\beta}{\eta_{t+1}}$$

$$\ln(\eta_t) = \rho_\eta \ln(\eta_{t-1}) + \varepsilon_{\eta,t}$$

- Decrease in η_t induces a drop in aggregate demand for goods.

The Shocks

- Production function for intermediate goods producing firms:

$$Y_t(j) = Z_t H_t(j)$$

- Neutral Technology Shock

$$\ln(Z_t) = \ln(G) + \ln(Z_{t-1}) + \varepsilon_{Z,t}$$

- No factor utilization margin and no investment.

The Shocks

- Monetary Policy

$$R_t = \max[1, R_t^*]$$

$$R_t^* = \left(\frac{\bar{\Pi} G}{\beta}\right)^{1-\rho_R} (R_{t-1}^*) \left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\gamma_\Pi} \left(\frac{Y_t}{G Y_{t-1}}\right)^{\gamma_y} \varepsilon_{R,t}$$

- Inertia in terms of notional interest rate rather than actual interest rate.

- R_t^* depends on the growth rate of output, not output gap.

Central Empirical Result

- Great Recession was triggered and prolonged by *extremely* unlikely sequence of negative discount rate, TFP shocks.
- Key force triggering the ZLB epsiode during 2008- 2009: a sequence of discount rate shocks.
- Productivity shocks played relatively larger role in slow output growth from 2009 on.
- Large, persistent fall in discount rate was relatively more important in explaining inflation, nominal interest rates.

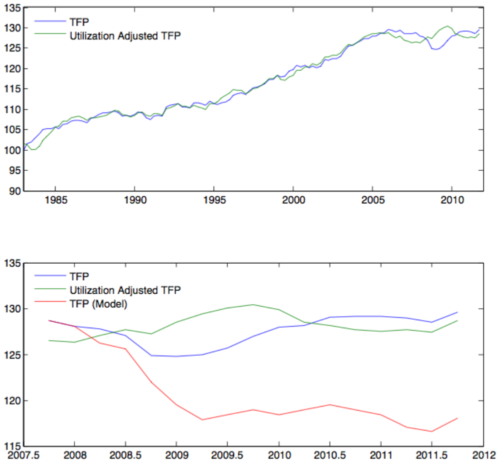
Problem

- Behavior of TFP in their model differs sharply from state-of-the-art (Fernald) estimates during the Great Recession itself.

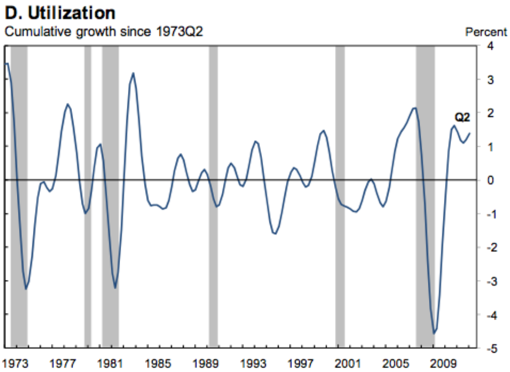
- Reason: model has no way to account for sharp rise in utilization rates that began at the end of 'official recession'.
  - There's no utilization in the model.
  - If there was, you'd need a rise in TFP or a rise in discount rate to generate rise in utilization rate.
  - Both these shocks would lead to a rise in aggregate demand.
  - ZLB episode would have been over much sooner.

- Model is missing *some* essential feature of the Great Recession.

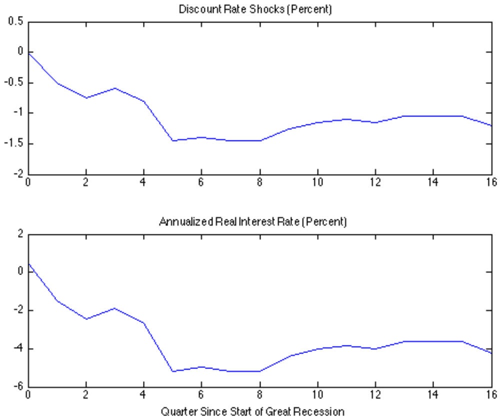
TFP and the Great Recession



Utilization



Model Implied Discount Rates



Ongoing importance of discount rate shocks

- Why do discount rate shocks play a key role in explaining behavior of inflation and the interest rate?
- Mean of posterior values for structural parameters implies a linearized slope coefficient for NK Phillips curve of 0.052.
  - Inflation is much more responsive to marginal costs / output gap than 'standard' estimates.
- So they're not explaining surprisingly high (non-negative) inflation rates in ZLB episode with very 'flat' Phillips curve.

Inuition

- Suppose we abstract from habit formation and consider periods where $R_t = 1$

$$\frac{Y_{t+1}}{Y_t} = \frac{\beta}{G\eta_t}\frac{1}{\Pi_{t+1}}$$

- Output growth has been very small (sometimes negative) relative to inflation.

- Need sequence of negative η_t shocks to reconcile the model with the data.

- Euler equation fiasco once again.

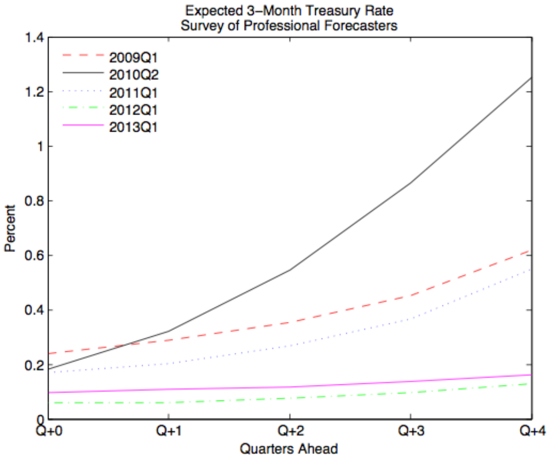
Duration of the ZLB

- Model *must* interpret duration of ZLB episode as reflecting extremely unusual sequence of negative discount rate, TFP shocks.

- Authors argue that private expectations have been consistent with a short *expected* duration of ZLB.
  - They make this argument using a proxy for market expectations as of 2009:1 and 2010:2.

- Consider mean forecasts of the 3-month T-bill rate from the survey of professional forecasters.

Forecasts



Expected 3–Month Treasury Rate
Survey of Professional Forecasters
2009Q1
2010Q2
2011Q1
2012Q1
2013Q1
Percent
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Q+0
Q+1
Q+2
Q+3
Q+4
Quarters Ahead

Explaining duration of the ZLB

- Suppose we also take into account other prolonged ZLB spells (Japan, Great Depression, ...).

- Seems clear (to me) that we need a model that doesn't explain long ZLB spells by highly unlikely sequence of extreme shocks.

Multiple Equilibria

- Authors briefly discuss possibility of multiple equilibria in their setting.
- They focus on existence of two steady states.
  - High and low (negative) inflation steady state (Benhabib, Schmitt-Grohe and Uribe (2001).
- Gust et. al. assume that once you exit ZLB, you switch to high inflation steady state (Eggertson and Woodford).
- Standard assumption in linearized analyses of ZLB.

A possible rationale

- Monetary policy rule: actually composed of the Taylor rule with escape clause
  - If inflation is not proceeding at its target rate, money growth rate is adjusted (Christiano and Rostagni, 2001).

- Let's maintain assumption that when ZLB episode is over, economy jumps to high inflation steady state.

Problem is much worse than 2 steady states

- If you don't linearize equilibrium conditions, there's multiple fundamental equilibria, sunspot equilibria even if you focus on high inflation steady state.
  - Braun-Körber-Waki (2012), CE (2012), Mertens-Ravn (2011).

- Not clear how to assess policy interventions in this type of world.

- Conditional on staying in one 'set' of equilibria, policies have very different implications
  - Government spending multiplier can be small in one set, large in another.

Multiple Equilibria

- What are the time series implications of such a model?
- How should a Bayesian or a classical statistician proceed?
- Did authors encounter multiple equilibria when they solved their model?

Refinements and multiplicity

- CE (2012) study properties of nonlinear ZLB equilibria in EW model.
- Suppose we impose the requirement that equilibria be E-learnable.
- Then the model has a unique equilibrium.
- Properties of this nonlinear equilibrium are similar to linearized equilibrium.

The Model

- Household preferences

$$E_0 \sum_{t=0}^{\infty} d_t \left[\log\left(C_t\right) - \frac{\chi}{2} h_t^2 \right]$$

- Household budget constraint, final good and intermediate firm problems same as in Gust et. al., but no technology shocks.

- Monetary policy rule is simpler

$$R_t = \max\left\{1, \frac{1}{\beta} + \alpha\left(\pi_t - 1\right)\right\}.$$

The Model

- Discount rate shock

$$
\begin{aligned}
d_t &= \begin{Bmatrix} \frac{1}{1+r_1}\frac{1}{1+r_2}\cdots\frac{1}{1+r_t}, & t \geq 1 \\ 1, & t = 0 \end{Bmatrix} \\
r_t &\in \left\{r^l, r^h\right\}, r^l < 0,\ r^h > 0.
\end{aligned}
$$

- Economy starts with $r_t = r^l < 0$ in initial period, with probability p, it stays there.

- Jump to r^h $(\equiv 1/\beta - 1)$ with constant probability $1 - p$.

- r^h is an absorbing state and economy reverts to high inflation steady state.

Baseline parameters

$$\begin{aligned} G/(G+C) &= 0.20,\ \beta = .99, \phi = 100, \chi = 1.25 \\ \alpha &= 1.5, p = .775, \\ r_l &= -.02/4. \end{aligned}$$

- Implied slope on marginal cost in log linearized Phillips curve, 0.03.

- 'High' inflation steady state

$$\pi = 1,\ C = 0.80,\ h = 1.001$$

Multiple Equilibria

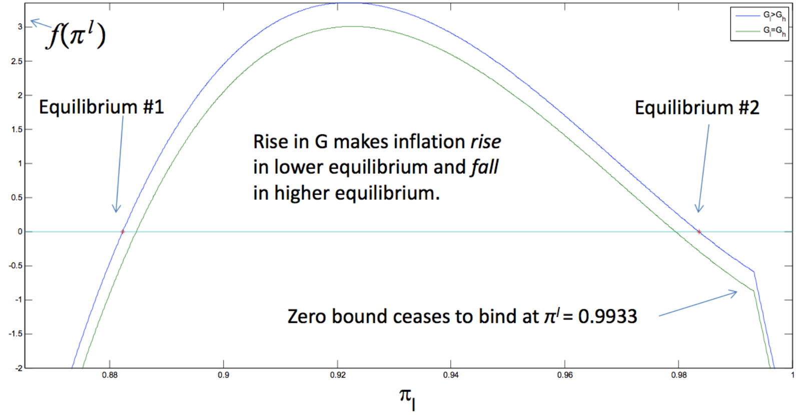
- We can reduce computation of $r = r^l$ equilibrium to one non-linear equation in π^l.

- Exists exactly two solutions for π^l.

Multiple Fundamental Equilibira

Figure 2: EW Equilibria

Interval of candidate EW equilibrium inflation rates: [0.78,2.27]. There are no other zeros.



Properties

Table 1: Properties of EW Equilibrium for Three Parameterizations			
Panel A: Baseline parameterization			
	equilibrium #1	equilibrium #2	log-linear
$\frac{d\text{GDP}}{dG}$	0.16	2.18	2.77
% drop in GDP	37.55	5.38	5.99
change in inflation rate	-11.77	-1.64	-1.90

Equilibrium #2 has properties that resemble the ones implied by the log-linear approximation.

But, equilibrium #1 is completely different!

Sunspot equilibria

- Assume $r^l = r^h$ so that one equilibrium is normal 'high-inflation' equilibrium.

- Second equilibrium: economy starts out in 'low' state, escapes with constant probability, $1 - p$.

- Shock driving economy into ZLB is loss in confidence.
  - Agents anticipate deflation, creating perception that real interest rate is high.
  - Households lower expenditures, drive the economy into a recession.
  - Marginal costs (wages) falls, creates downward pressure on price level.
  - Price-setting frictions generate sustained fall in price level.
  - So initial fear of deflation is self-fulfilling.

E-Learnability

- If economy converges to equilibrium under a model with learning after a deviation from rational expectation beliefs, equilibrium is 'E-Learnable'.

- Suppose agents know values of variables outside ZLB, value of government consumption in all periods and states.

- Agents use 'no change' assumption to forecast inflation, aggregate quantities and their own choices in the future scenario where ZLB binds.
  - These assumptions are correct in the rational expectations equilibrium.

Result

- *Only* equilibrium 2 is stable.
  - That equilibrium looks like unique 'linear' equilibrium in ZLB analyses.

- Very low inflation, low fiscal multiplier fundamental equilibrium isn't E-learnable.

- Sunspot equilibria aren't E-learnable.

- Do these conclusions hold in Gust et. al. environment?

Approximations?

- According to CE, evidence that quality of linear approximations is poor rests on examples where output deviates by more than 20 percent from its steady state.

- For perturbations of reasonable size, conclusions arrived at in ZLB analysis using linear approximations appear to be robust.

- But those approximations may not be good enough for estimation exercises.

Conclusion and conundrums

- This paper is extremely ambitious and makes a very nice methodological contribution.

- But given the trade-offs required for estimation, we should be skeptical about substantive inferences authors make about the Great Recession.

- In the short run, we face difficult trade-offs between our desire to:
  - Estimate models with ‘full information methods’,
  - Work with complex, empirically plausible models,
  - Desire to work with explicit non-linear solutions.