The Empirical Implications of the Interest-Rate Lower Bound

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Motivation

- The ZLB can limit the corrective response of monetary policy to adverse shocks. A key question is how much did the ZLB constrain policy during the last recession.
- We address this question by estimating a nonlinear version of a New Keynesian model widely used in monetary economics.
- Our methodology can be applied in other contexts in which occasionally binding constraints have important economic consequences (e.g., financial constraints).

Preview of Main Results

- Our estimates suggest that 20% of the drop in U.S. GDP during the last recession was due to the ZLB.

- The credibility of this finding depends upon the empirical plausibility of our model. We find that:

  - The model provides a reasonably good fit of the dynamics for output, inflation, and the nominal interest rate.

  - The model matches up well with evidence from financial markets and professional forecasters regarding the expected duration of the ongoing ZLB spell. Matches this evidence even though it was not used to estimate the model.

Key Features of the Model

- A nonlinear New Keynesian model featuring:
    - Representative household with habits for consumption.
    - Monopolistically-competitive firms that face adjustment costs in changing prices.
    - Monetary policy operates according to an interest rate rule that is constrained by the lower bound.
    - The sources of uncertainty are a *unit root* shock to technology, and *AR(1)* shock to the intertemporal allocation of demand, and an *iid* monetary policy surprise.

Nonlinear Equilibrium Conditions

- An intertemporal Euler equation:

$$\lambda_t = \frac{\beta}{\eta_t} R_t E_t \left\{ \lambda_{t+1} \ \pi_{t+1}^{-1} \right\}, \quad \text{where } \lambda_t = \left[c_t - \gamma c_{t-1} \right]^{-1}$$

- A price-setting relationship:

$$\left(\frac{\pi_t}{\overline{\pi}}\text{-}1\right)\frac{\pi_t}{\overline{\pi}} = \frac{\beta}{\eta_t} E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \frac{y_{t+1}}{y_t} \left(\frac{\pi_{t+1}}{\overline{\pi}}\text{-}1\right) \frac{\pi_{t+1}}{\overline{\pi}} \right\} - \frac{\epsilon - 1}{\varphi} + \frac{\epsilon}{\varphi} \frac{1}{\lambda_t}$$

$$y_t = c_t + \frac{\varphi}{2}\left(\frac{\pi_t}{\overline{\pi}}\text{-}1\right)^2 y_t \qquad y_t = Z_t h_t$$

- An interest rate rule for the desired or notional interest rate:

$$R_t^* = \left(\frac{\overline{\pi} G}{\beta}\right)^{1-\rho_R} \left(R_{t-1}^*\right)^{\rho_R} \left(\frac{\pi_t}{\overline{\pi}}\right)^{\gamma_\pi} \left(\frac{y_t}{y_{t-1}}\right)^{\gamma_y} \exp(\varepsilon_{R,t})$$

- Lower bound constraint:

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

Solution Method

- We could have imposed the ZLB but log-linearized the remaining equilibrium conditions (i.e., constrained linear). We found this solution method inaccurate at the lower bound.
- Instead, we use a projection method: collocation along with Chebychev polynomials.
- We do not approximate the decision rules with polynomials directly. Our approximation takes a piecewise approach to account for the kink associated with the lower bound.
- We find a large improvement in accuracy from this approach relative to the constrained linear approach.

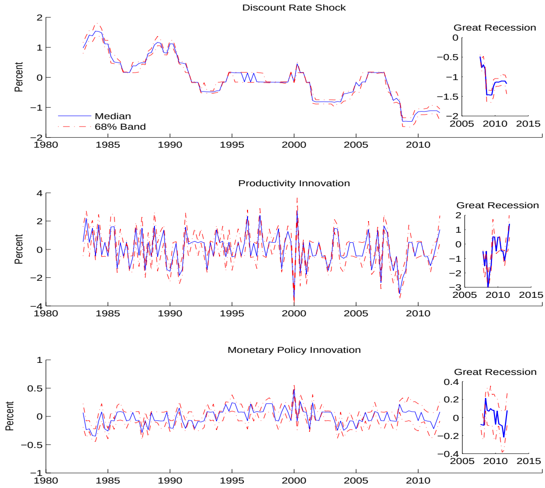
Estimation Procedure

- We use the particle filter within a Metropolis-Hastings (MH) algorithm.
- As observables, we use U.S. data on GDP growth, inflation, and the nominal interest rate from 1983Q1-2011Q4.
- We follow Smith (2011) and introduce a surrogate into the MH algorithm. The surrogate is used to prescreen proposed values to avoid expensive likelihood evaluations. For our surrogate, we use linearization with the Kalman filter.

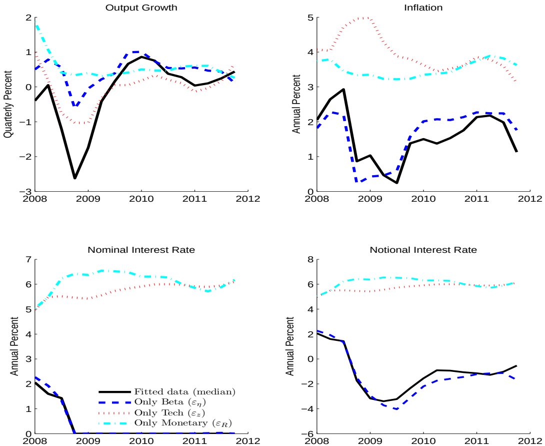
Posterior Distribution of Selected Parameters

parameter	mean	stdev	prior type	prior mean	prior stdev
γ	0.47	0.06	Beta	0.50	0.22
φ	94.2	14.9	Gamma	85.0	15.0
γ_π	0.79	0.11	Normal	0.0	1.0
γ_y	0.25	0.049	Normal	0.0	1.0
ρ_R	0.86	0.035	Beta	0.50	0.28
ρ_η	0.88	0.018	Beta	0.50	0.28

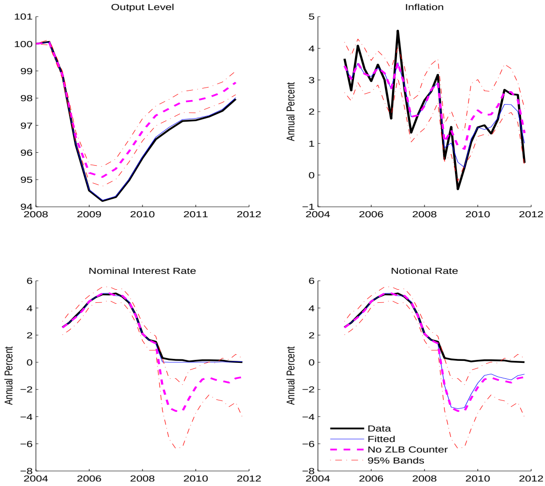
The Path of Estimated Shocks



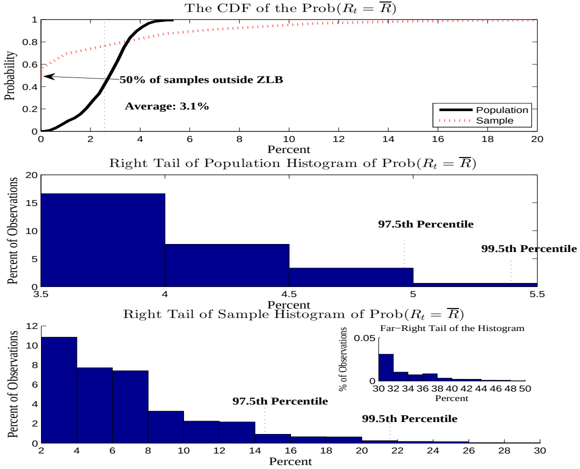
What pushed the economy to the ZLB?



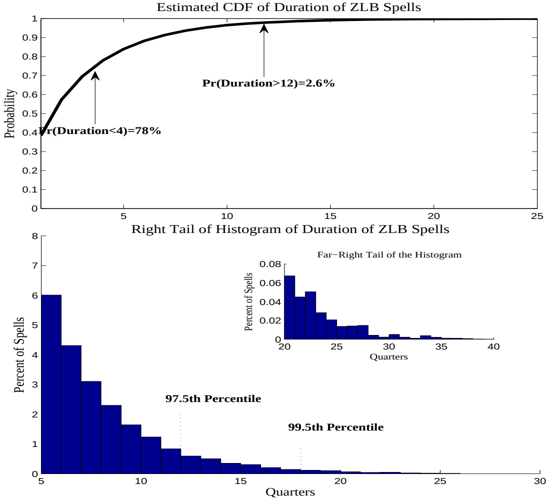
Contribution of the ZLB to the Great Recession



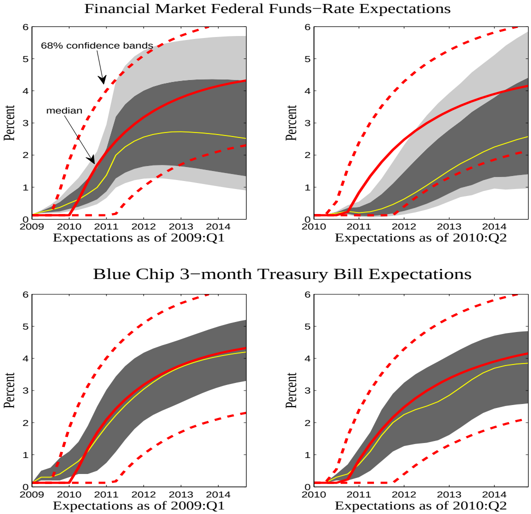
Distribution of the Probability of Hitting the ZLB



Distribution of the Duration of a ZLB Spell



Expected Duration of U.S. Lower Bound Spell



Conclusions

- The ZLB constraint was a signficant factor in exacerbating the last recession; accounted for 20% of the drop in output.
- Duration of the ZLB spell implied by the model in line with financial markets and Blue-Chip expectations: the protracted nature of the ongoing ZLB spell was largely unexpected.
- Ongoing work: Extend the model to incorporate endogenous capital and financial frictions to better account for the nature of the shocks that push the economy to the ZLB and their effects on the composition of aggregate demand.
- Apply our methodology to the Great Depression and Japan.

Thank you for your attention.

Figure 1: Smoothed Estimates of Model Objects

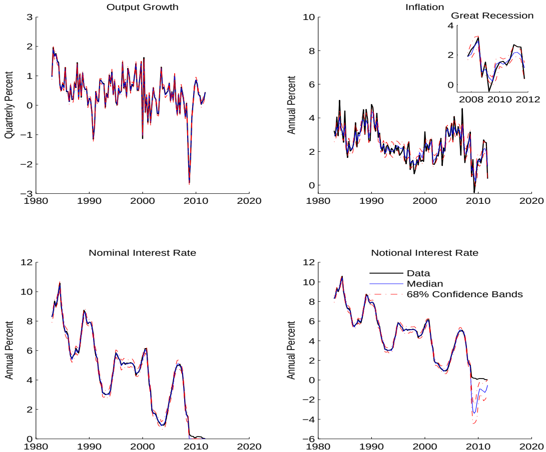


Figure 2: The Dynamic Path of Alternative Initial Conditions

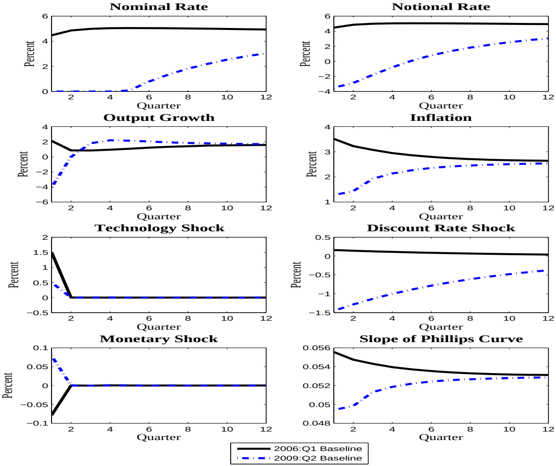


Figure 3: The Effects of a Discount Rate Shock

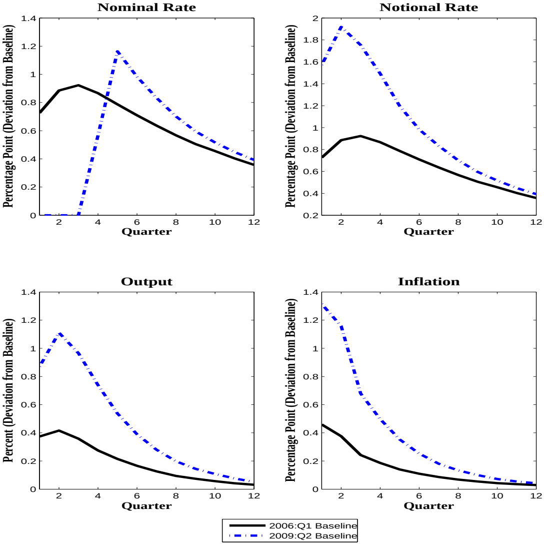


Figure 4: The Effects of a Producitivity Shock

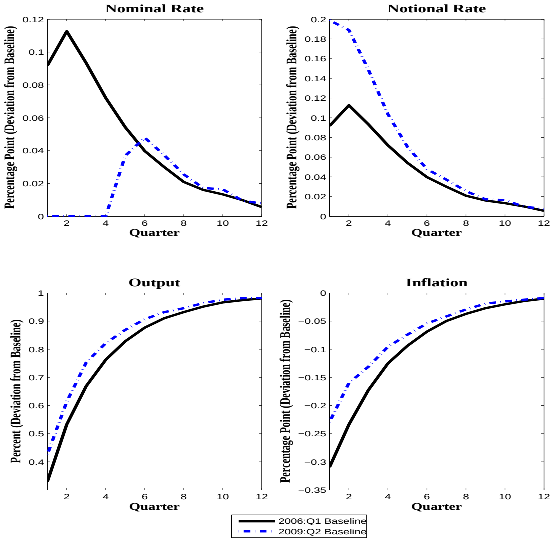


Figure 5: The Path of the Estimated Shocks

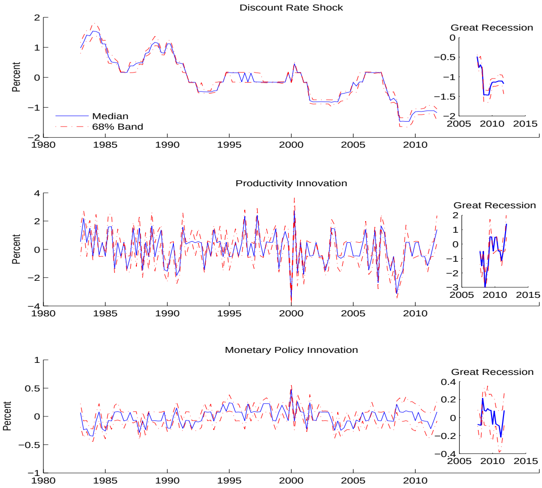


Figure 11: The Dynamic of Short and Long Lower Bound Spells

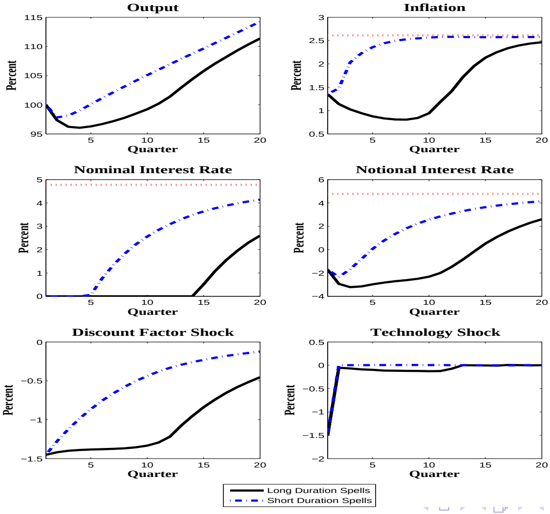


Figure B.1: Comparison of Model Solutions (2009:Q2 Initial Conditions)