Understanding the Great Recession

Christiano, Eichenbaum and Trabandt

University of Pennsylvania, April 23, 2014.

Background

- GDP appears to have suffered a permanent (10%?) fall since 2008.
- Trend decline in labor force participation accelerated after the 'end' of the recession in 2009.
- Unemployment rate persistently high
    - recent fall primarily reflects the fall in labor force participation.
- Employment to population ratio fell sharply with little evidence of recovery.
- Vacancies have risen, but unemployment has fallen relatively little ('shift in Beveridge curve', 'mismatch').
- Investment and consumption persistently low.

Questions and Answers

- What forces drove real quantities in the Great Recession?

  – Shocks to intertemporal margins ('financial markets') key drivers, even for variables like labor force participation.

  – Government shocks not important: because of size and timing (consistent with ZLB literature).

- Why was the drop in inflation so moderate?

  – Effect of financial market shocks on cost of working capital.

  – Fall and slow recovery in TFP.

- Mismatch in the labor market?

  – Not a first order feature of the Great Recession.

  – We have no problem explaining the 'shift' in the Beveridge curve, without resorting to structural shifts in the labor market.

What Sort of Model do we Need?

- The labor market is a big part of the puzzle.
  - need a model with endogenous labor force participation, unemployment, vacancies, etc.
- Need investment and capital.
- Incorporate price-setting frictions.
  - We stress interaction of shocks with zero lower bound (ZLB).
    - The ZLB doesn't matter in a (version of our) model with flexible prices.
- Work with a modified New Keynesian DSGE model.
  - Forces are captured in the form of 'wedges'.
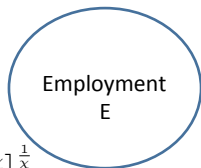 - That is, we avoid microfounding the shocks.

Outline

- Mostly, a standard 'medium sized' DSGE model

- Must adapt the labor market side of the model:
  - adopt DMP-style matching and bargaining between firms and workers.
  - to have any hope of accounting for observed labor market volatility,
    - environment must be characterized by wage inertia.
    - for this, we adopt the alternating offers bargaining described in Christiano-Eichenbaum-Trabandt (build on Hall-Milgrom).
    - we have no need to make wages exogenously 'sticky'.

- Estimate model using pre-2008 data.

- Use estimated model to analyze post-2008 data.
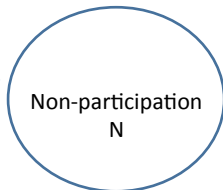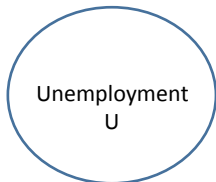
Labor Market
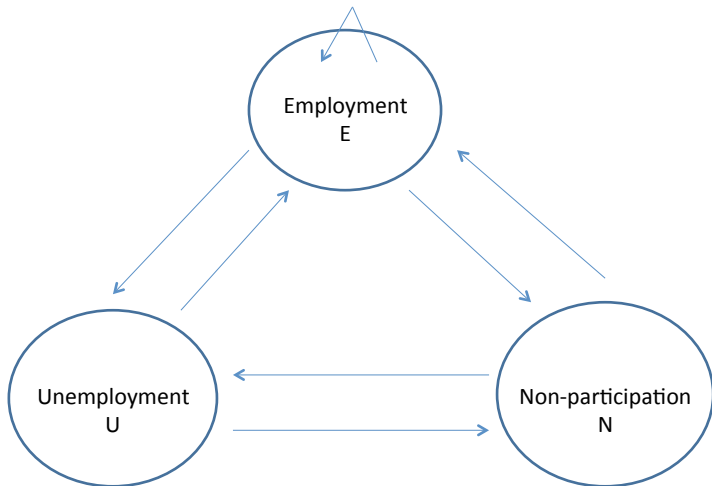
Labor Market

$$E_0 \sum_{t=0}^{\infty} \beta^t \mathcal{U}(\tilde{C}_t)$$

$$\tilde{C}_t = \left[(1-\omega)(C_t)^\chi + \omega \left(C_t^H\right)^\chi \right]^{\frac{1}{\chi}}$$

$$C_t^H = (1 - L_t)^{1-\alpha_c} (L_t - l_t)^{\alpha_c}$$

Employment
E

Unemployment
U

Non-participation
N

-Household labor force decision
-Split between U and E determined by job-finding rate.

Labor Market

$$\max_{\{C_t, L_t, C_t^H, B_{t+1}, K_{t+1}, I_t, l_t\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \mathcal{U}(\tilde{C}_t)$$

Employment
E

$$P_t C_t + P_{I,t} I_t + B_{t+1}$$
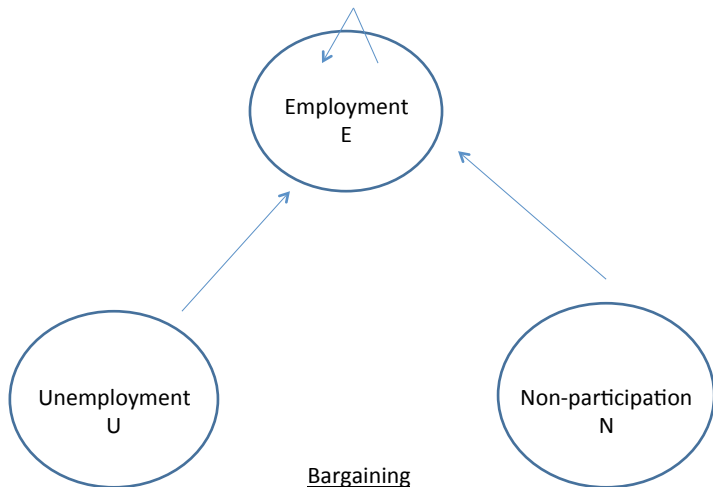$$\leq \quad R_{K,t} K_t + (L_t - l_t) P_t D_t + l_t W_t + R_{t-1} B_t - T_t$$

$$K_{t+1} = (1 - \delta_K) K_t + [1 - S(I_t/I_{t-1})] I_t$$

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U

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Labor Market

Employment
E

Unemployment
U

Non-participation
N

Bargaining
Three types of worker-firm meetings:
i) E to E , ii) U to E, iii) N to E

End of Period Labor Market Flows

- Unemployed and just-separated workers at end of $t-1$:

$$\overbrace{(1-\rho)\ \overbrace{l_{t-1}}^{\text{employed in } t-1}}^{\text{separated workers at end of } t-1} + \overbrace{\overbrace{L_{t-1}}^{\text{labor force in } t-1} - l_{t-1}}^{\text{unemployed in } t-1}$$

$$= \ (1-\rho)\,l_{t-1} + L_{t-1} - l_{t-1}$$

$$= \ L_{t-1} - \rho l_{t-1}.$$

- Some thrown exogenously into non-employment:

$$\overbrace{s\,(L_{t-1} - \rho l_{t-1})}^{\text{stay and search for jobs}} ,\ \overbrace{(1-s)\,(L_{t-1} - \rho l_{t-1})}^{\text{go into non-employment}}$$

Beginning of Period Job Search

- Labor force at start of time t :

$$L_t \ = \ \overbrace{s\left(L_{t-1} - \rho l_{t-1}\right)}^{\text{period } t-1 \text{ unemployed and separated who stay in labor force}}$$

$$+ \ \overbrace{\rho l_{t-1}}^{\text{people that were employed in previous period and remain attached}}$$

$$+ \ \overbrace{r_t}^{\text{people sent to labor force from non-employment}}$$

- Number of people searching for jobs at start of time t :

$$r_t + s\left(L_{t-1} - \rho l_{t-1}\right) = L_t - \rho l_{t-1}.$$

Job Finding

- Total meettings between workers and firms at start of t :

$$l_t = (\rho + x_t)\, l_{t-1} = \rho l_{t-1} + f_t \overbrace{(L_t - \rho l_{t-1})}^{r_t + s(L_{t-1} - \rho l_{t-1})} ,$$

  where

$$f_t = \frac{\overbrace{x_t l_{t-1}}^{\text{aggregate hiring rate}}}{L_t - \rho l_{t-1}} .$$

- Workers and firms that meet, begin to bargain.
  - In equilibrium, meetings turn into matches.

Modified version of Hall-Milgrom

- Firms pay a fixed cost to meet a worker (must post vacancies, but these are costless).

- Then, workers and firms engage in alternating-offer bargaining.
  - Better off reaching agreement than parting ways.
  - Disagreement leads to continued negotiations.

- If bargaining costs don't depend too sensitively on state of economy, neither will wages.
  - firms suffer cost, γ, when they reject an offer by the worker and make a counteroffer.
  - costs somewhat sensitive to state of business cycle:
    - protracted negotiations mean lost output/wages.
    - rejection of an offer risks, with probability δ, that negotiations break down completely.

- After expansionary shock, rise in wages is relatively small.

Other Labor Market Variables: Vacancies.

- Empirical measure of vacancies (JOLTS):
  - position posted by an establishment, which it would fill if it met a suitable candidate.
  - compare vacancies in model with JOLTS.
- Vacancies in our model.
  - vacancies costless, but firm must post them to hire.
  - if firm wants to hire h workers it must post

  $$v = \frac{h}{Q}$$

  vacancies (it takes Q as given).
  - vacancies posted at the level of the establishment (firm has many establishments).
    - if a vacancy produces a suitable candidate, he/she is hired.
- Q determined in the 'normal way':

  $$Q = \frac{\text{agg hires}}{\text{agg vacancies}}$$

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  $$Q = \frac{\text{agg hires}}{\text{agg vacancies}} = \text{constant} \times \left(\frac{\text{agg job searchers}}{\text{agg vacancies}} \right)^{\sigma}$$

Value functions for Workers and Firms

- Worker value functions:

$$
\begin{aligned}
V_t \;=\; & w_t + E_t m_{t+1}[\rho V_{t+1} \\
& + (1-\rho)\,s\,(f_{t+1}\bar{V}_{t+1} + (1-f_{t+1})\,U_{t+1}) \\
& + (1-\rho)\,(1-s)\,N_{t+1}].
\end{aligned}
$$

$$
\begin{aligned}
U_t \;=\; & D + E_t m_{t+1}[sf_{t+1}V_{t+1} \\
& + s\,(1-f_{t+1})\,U_{t+1} + (1-s)\,N_{t+1}]
\end{aligned}
$$

$$
\begin{aligned}
N_t \;=\; & E_t m_{t+1}[e_{t+1}\,(f_{t+1}V_{t+1} + (1-f_{t+1})U_{t+1}) \\
& + (1-e_{t+1})\,N_{t+1}] \\
e_t \;=\; & \frac{r_t}{1-L_{t-1}}
\end{aligned}
$$

- Firm value function:

$$
J_t = \vartheta_t - w_t + \beta E_t m_{t+1} J_{t+1}
$$

Rest of Model is Standard, Medium-Sized DSGE

- Competitive final goods production: $Y_t = \left[\int\limits_0^1 Y_{j,t}^{\frac{1}{\lambda_f}} dj \right]^{\lambda_f}$.

- j^{th} input produced by monopolistic 'retailers':

    - Production: $Y_{j,t} = k_{j,t}^\alpha \left(z_t h_{j,t} \right)^{1-\alpha} - \phi$.
    - Homogeneous good, $h_{j,t}$, purchased in competitive markets for real price, ϑ_t.
    - Retailers prices subject to Calvo sticky price frictions (no price indexation).

- Homogeneous input good h_t produced by the firms in our labor market model, 'wholesalers'.

- Taylor rule.

Estimated Parameters, Pre-2008 Data

- Estimation by impulse response matching, Bayesian methods.

- Prices change on average every 4 quarters.

- δ : roughly 0.1% chance of a breakup after rejection.

- γ : cost to firm of preparing counteroffer roughly 1 day's production.

- Posterior mode of hiring cost: 0.49% of GDP; replacement ratio: 17% of wage.

- Elasticity of substitution between home and market goods: 3.
    - set *a priori*, see Aguiar-Hurst-Karabarbounis (2012).

Responses to Three Shocks

- Monetary policy and two technology shocks.
- Responses in model resemble responses in data.
- For example: inflation, output, wages and labor market respond roughly as they do in the data.
  - no Shimer puzzle.

Accounting for the Great Recession

- Use model to assess which specific shocks account for gap between:
    - What actually happened.
    - What would have happened in absence of the shocks.

The U.S. Great Recession

Data
2008Q2
Linear Trend from 2001Q1 to 2008Q2
Forecast 2008Q3 and beyond

Notes: Gray areas indicate NBER recession dates.
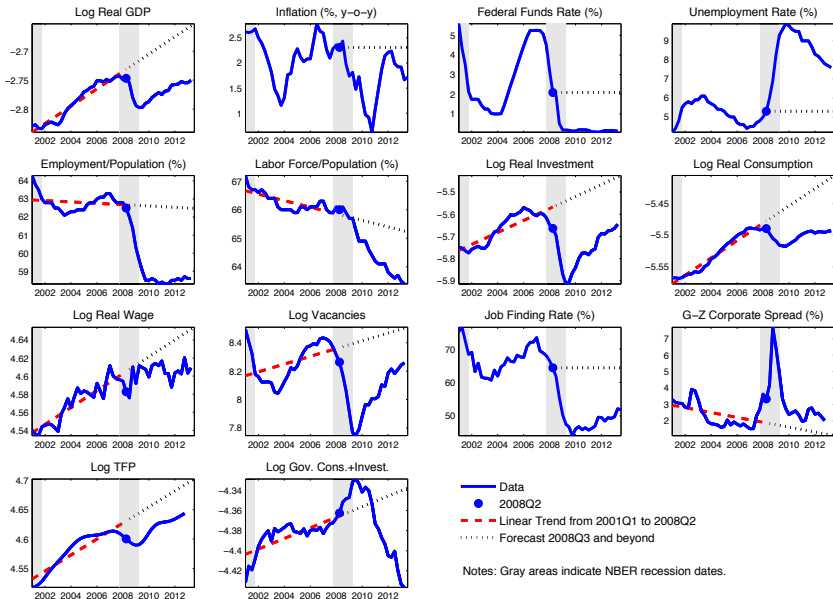
Same Data, with Nonresidential Investment

Log Real GDP

Inflation (%, y–o–y)

Federal Funds Rate (%)

Unemployment Rate (%)

Employment/Population (%)

Labor Force/Population (%)

Log Non–Residential Investment

Log Real Consumption

Log Real Wage

Log Vacancies

Job Finding Rate (%)

G–Z Corporate Spread (%)

Log Gov. Cons.+Invest.

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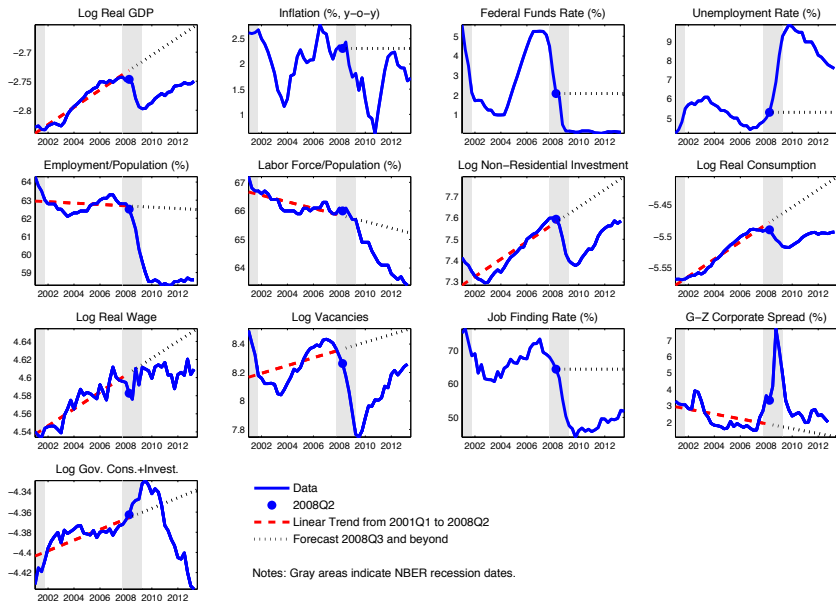
The U.S. Great Recession: Data Targets
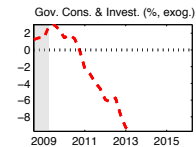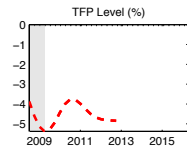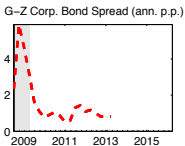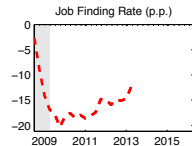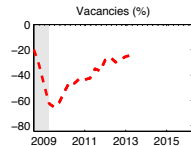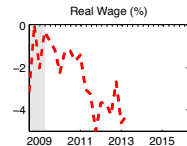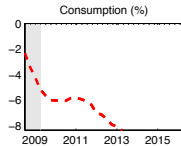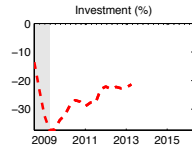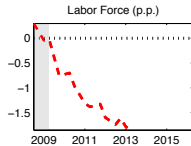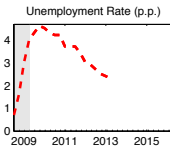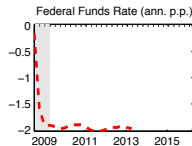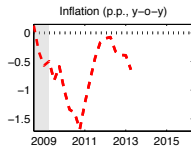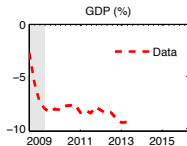
Monetary Policy in the Great Recession

- From 2008Q3 to 2011Q2:
  - Taylor-style monetary policy rule -

$$\ln(Z_t) = \ln(R) + \overset{1.7}{\overbrace{r_\pi}} \ln\left(\pi_t^A / \pi^A\right) + 0.25 \overset{0.015}{\overbrace{r_y}} \ln\left(\mathcal{Y}_t / \mathcal{Y}_t^*\right)$$
$$+ 0.25 \overset{0.231}{\overbrace{r_{\Delta y}}} \ln\left(\mathcal{Y}_t / (\mathcal{Y}_{t-4} \mu_{\mathcal{Y}}^A)\right) + \sigma_R \varepsilon_{R,t}.$$

  - The actual policy rate, R_t:

$$\ln(R_t) = \max\left\{\ln(1), \rho_R \ln(Z_{t-1}) + (1 - \rho_R) \ln(Z_t)\right\}$$

- After 2011Q2 - 'forward guidance'
  - following a one year transition, 'Evans rule'
  - keep funds rate at zero until either unemployment falls below 6.5 percent or inflation rises above 2.5 (APR).

Two Financial Market Shocks

❶ *Consumption wedge,* Δ_t^b: Shock to demand for safe assets ('Flight to safety'):

$$1 = (1 + \Delta_t^b)E_t m_{t+1} R_t / \pi_{t+1}$$

❷ *Financial wedge,* Δ_t^k: motivated by financial frictions literature. Reduced form of 'risk shock', Christiano-Davis (2006), Christiano-Motto-Rostagno (*AER* 2014), CKM:

$$1 = (1 - \Delta_t^k)E_t m_{t+1} R_{t+1}^k / \pi_{t+1}$$

- Financial wedge also applies to working capital loans:
  - Interest charge on working capital: $\alpha R_t \left(1 + \Delta_t^k\right) + 1 - \alpha$
  - $\alpha = \frac{1}{2}$ is share of inputs financed with loans.

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  - $\alpha = \frac{1}{2}$ is share of inputs financed with loans.
 - Higher financial wedge directly increases cost to firms.

Measurement of Shocks

- Financial wedge, $1 - \Delta_t^k$, measured using GZ spread data.

- Government shock measured using G data.

- Neutral technology shock based on TFP data.

- We do not have data on the consumption wedge, Δ_t^b.
    - Initially, agents expect Δ_t^b to jump from 1 to 1.0035 until 2013Q3
        - this represents a 1.3 percentage point (ARP) drop in households' discount rate.
        - compares with 6 percentage point drop in Eggertsson and Woodford.
    - In 2012Q2 households revise their expectation, expect Δ_t^b to remain up until 2015Q2.
        - Stand-in for problems of 'fiscal cliff' and sequester.
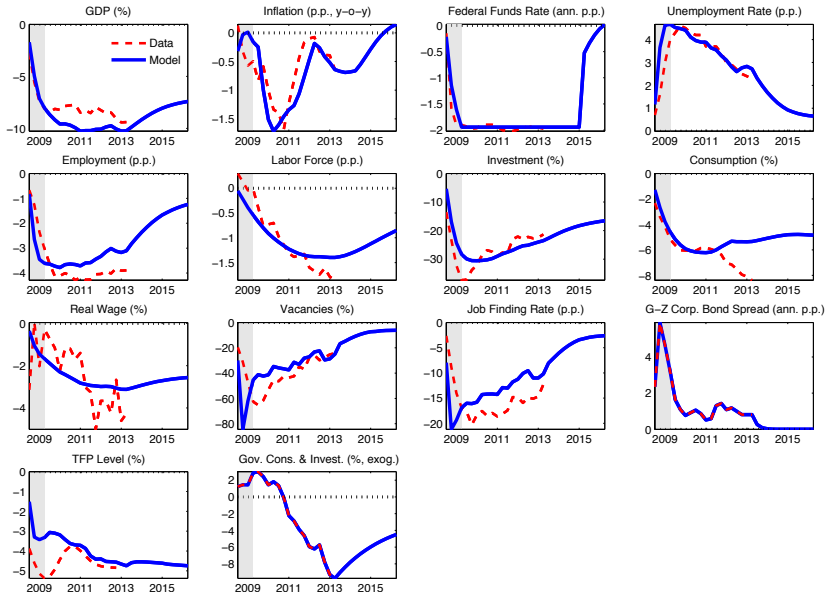   - Helps model account for weak consumption observed after 2011.

Stochastic Simulation of the Model

- Apply a stochastic 'shooting' method.

- Impose certainty equivalence
  - - replace things like $E_t f\left(x_{t+j}\right)$ with $f\left(E_t x_{t+j}\right)$, for $j > 0$.

The U.S. Great Recession: Data vs. Model
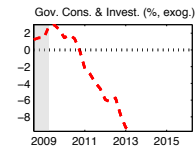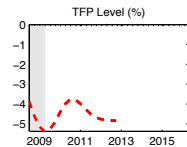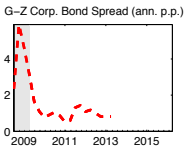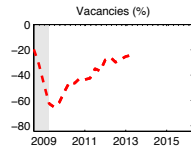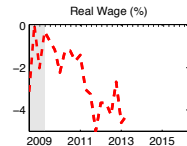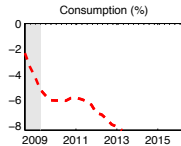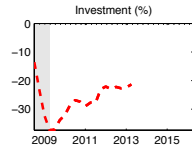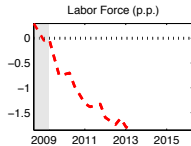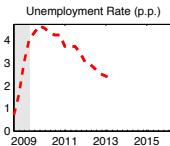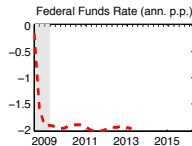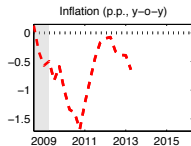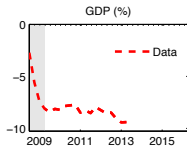
The U.S. Great Recession: Data vs. Model

Decomposing What Happened into Shocks and Policy

- Our shocks roughly reproduce the actual data.
- We investigate the effect of a shock by shutting it off.
  - Resulting decomposition is not additive because of nonlinearity.

- Results:
  - Financial wedge shock - accounts for the biggest effect on real quantitites.
  - Flight to quality shock - drives economy into lower bound, pushes down inflation.
  - Government spending - small role.
  - TFP shock - plays an important role in preventing drop in inflation.
  - Forward guidance - prevented interest rate 'lift off' that would have occured in 2012, and prevented additional economic weakness due to 'flight to quality shock'.

Effects of Financial Wedge Shock

- Accounts for the biggest effect on real quantities.

- Rise in financial wedge represents tax on intertemporal margin.

- With efficient markets: substitution from investment to consumption.
    - Accomplished by large drop in interest rate.
    - BUT: drop not feasible when ZLB is hit.
    - So, consumption not stimulated -> recession.
    - Drop in investment and consumption -> GDP must fall.
    - Households see terrible labor market -> keep people at home.
        - Labor force drops less than employment -> unemployment rises.
    - Recession leads to lower marginal costs -> inflation falls.

Phillips Curve

- Widespread skepticism that NK model can account for modest decline in inflation during the Great Recession.

- One response: Phillips curve got flat or always was very flat (Christiano-Eichenbaum-Rebelo, JPE 2011).

- Alternative: standard Phillips curve misses sharp rise in costs
  - unusually high cost of credit to finance working capital.
    - firm-level data suggests that firms with financial problems raise prices relative to firms not with financial difficulties (Gilchrist, Schoenle, Sim and Zakrajcek, 2013).
  - fall in TFP.

# Decomposition for Inflation
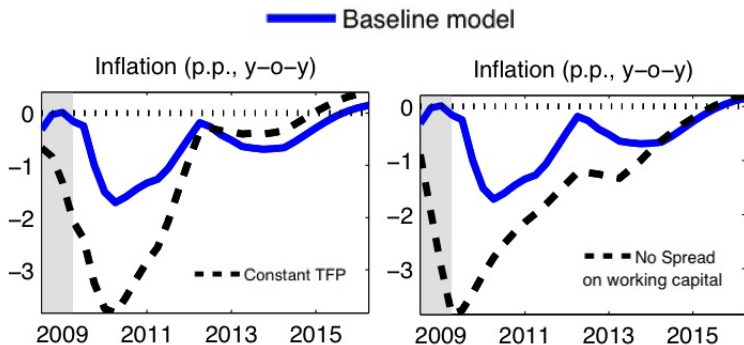
Beveridge Curve

- Much attention has focused on the 'sharp' rise in vacancies and relatively small fall in unemployment

    - it is claimed that this fish hook shape is evidence of a structural break in the matching function.

    - this claim is misleading for understanding the Great Recession, since it assumes unemployment is at a steady state level.

- In our model, no shift occurs in the matching technology.

    - if anything, our model predicts an even bigger 'shift' than occured.

The Beveridge Curve: Data vs. Model

Figure 15: Beveridge Curve: Data vs. Model
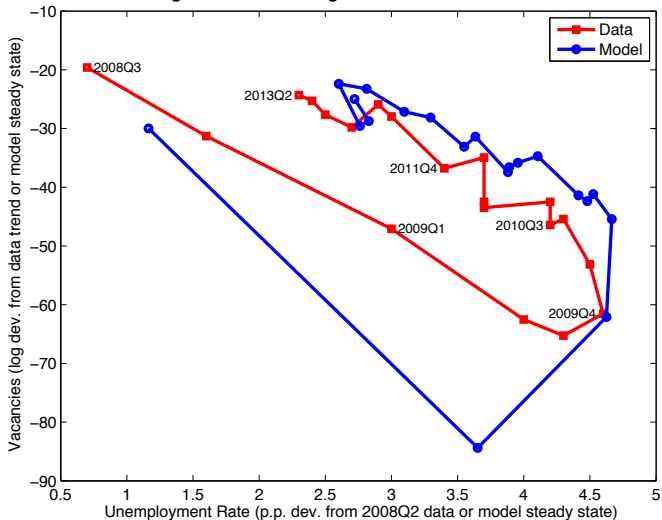
Model Predicts Fish Hook, Why?

- Simplest DMP style model

$$U_{t+1} - U_t = (1 - \rho)(1 - U_t) - f_t U_t$$

solving for f_t :

$$f_t = (1 - \rho)\frac{(1 - U_t)}{U_t} - \frac{U_{t+1} - U_t}{U_t} \overbrace{=}^{\text{matching function}} \sigma_t(\frac{V_t}{U_t})^\alpha$$
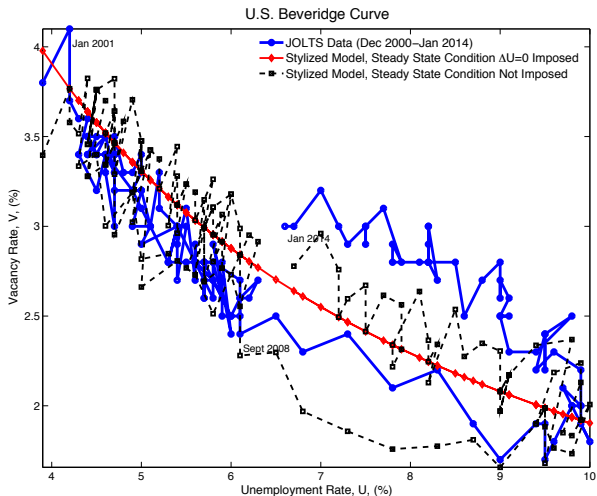
solving for V_t :

$$V_t = \left[(1 - \rho)\frac{(1 - U_t)}{\sigma_t U_t^{1-\alpha}} - \overbrace{\frac{U_{t+1} - U_t}{\sigma_t U_t^{1-\alpha}}}^{\text{standard approximation sets this to zero}} \right]^{1/\alpha}$$

- Naturally implies a 'fish hook' pattern.

Magnitude of Fish Hook in DMP Model

U.S. Beveridge Curve

$(\rho = 0.97, \alpha = 0.6, \sigma = 0.84,$ monthly$)$

Fish Hooks in Other Recessions

U.S. Beveridge Curve

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Fish Hooks in Other Recessions

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Fish Hooks in Other Recessions

U.S. Beveridge Curve

Fish Hooks in Other Recessions

U.S. Beveridge Curve
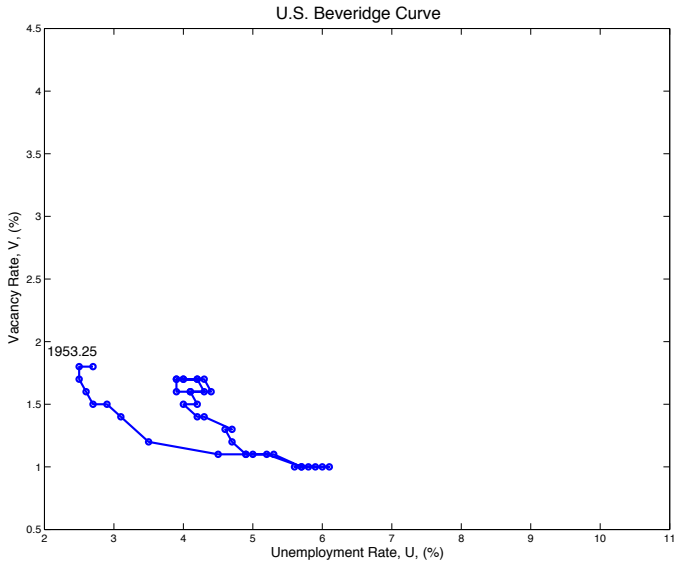
Fish Hooks in Other Recessions

Fish Hooks in Other Recessions

U.S. Beveridge Curve

Fish Hooks in Other Recessions

U.S. Beveridge Curve
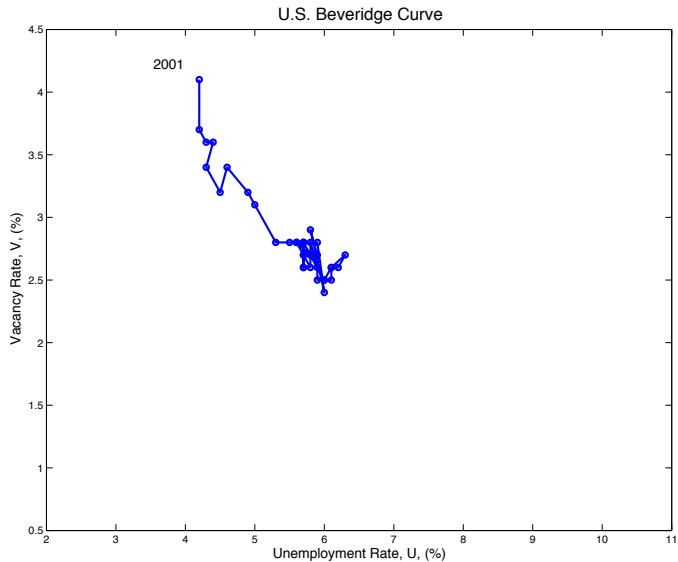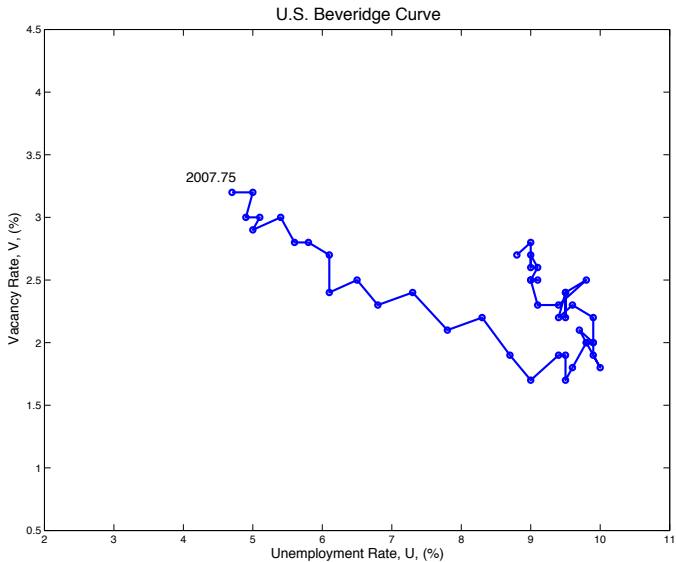
Conclusion

- Bulk of movements in aggregate real economic activity during the Great Recession can be accounted for as reflecting financial frictions interacting with the ZLB.

  - ZLB has caused negative shocks to aggregate demand to push the economy into a prolonged recession.

- Findings based on looking through lense of a New Keynesian model:

  - firms face moderate degrees of price rigidities,
  - no sticky wages.

- Find no evidence for 'mismatch' in labor market.

- Modest fall in inflation is not a puzzle once fall in TFP and working capital channel are taken into account.