The Labor Market in the New Keynesian Model: Changing the Bargaining Arrangement and Solving the Shimer Puzzle

Lawrence J. Christiano

April 24, 2013

Background

- In the version of the New Keynesian model with search/matching:
  - volatility of labor market in response to monetary policy and technology shocks is too small.
- Characterization of the problem considered here:
  - after a shock that increases firms' revenues from labor,
    - firms have an incentive to expand employment
  - but, as the job finding rate increases, worker bargaining power improves and wages rise
    - this reduces and nearly cancels firms' incentives to expand employment ('Shimer puzzle')

What We Do Here

- We
  - keep the hiring specification
  - change the model of bargaining, following Hall-Milgrom (2008) suggestion.
- Basic HM idea:
  - When workers and firms bargain, they think they're better off reaching agreement than parting ways.
    - so, disagreement would lead to continued negotiations.
  - If negotiation costs don't depend sensitively on state of economy, neither do wages.
- Muted response of wage
  - allows employment to expand vigorously in wake of expansionary shock.
  - helps account for the inertial response of inflation to a monetary policy shock.

Outline

- Model of household and goods-producing firms same as in previous handout.
  - briefly summarize this, for completeness.
- Labor market.
  - Change the way bargaining is done.
  - Alternating offer bargaining, as in Rubenstein (1982) and Binmore, Rubenstein and Wolinsky (1986).
  - Only one change to equilibrium conditions: replace Nash sharing rule with an alternative sharing rule.
- Solve and analyze the model.

Households and Firms

- Household intertemporal condition:

$$\begin{aligned}
\frac{1}{X_t} &= E_t \frac{1}{X_{t+1} R^*_{t+1}} \frac{R_t}{\bar{\pi}_{t+1}}, \\
R^*_{t+1} &\equiv \frac{1}{\beta} \exp\left(a_{t+1} - a_t\right) \\
X_t &\equiv \frac{C_t}{\exp\left(a_t\right)},\ \bar{\pi}_t = 1 + \pi_t.
\end{aligned}$$

- After linearization about zero inflation steady state:

$$\boxed{\begin{array}{l}
x_t = E_t x_{t+1} - E_t\left[r_t - \pi_{t+1} - r^*_t\right], x_t \equiv \hat{X}_t \equiv \frac{dX_t}{X} \\
\hline
r^*_t = -\log\left(\beta\right) + E_t\left[a_{t+1} - a_t\right], r^*_t \equiv E_t \log R^*_{t+1}.
\end{array}}$$

Goods Production

- Final good firms solve

$$\max P_t Y_t - \int_0^1 P_{i,t} Y_{i,t} dj, \text{ s.t. } Y_t = \left[\int_0^1 Y_{i,t}^{\frac{\varepsilon-1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}}.$$

- Demand curve for i^{th} monopolist:

$$Y_{i,t} = Y_t \left(\frac{P_t}{P_{i,t}} \right)^{\varepsilon}.$$

- Production function:

$$Y_{i,t} = \exp\left(a_t\right) h_{i,t},\ a_t = \rho_a a_{t-1} + \varepsilon_t^a,$$

where $h_{i,t}$ is a homogeneous input (not labor!) with after-subsidy nominal price, $(1-\nu)\,\vartheta_t P_t$.

- Calvo Price-Setting Friction:

$$P_{i,t} = \begin{cases} \tilde{P}_t & \text{with probability } 1-\theta \\ P_{i,t-1} & \text{with probability } \theta \end{cases}.$$

Optimal Price Setting

- As in baseline NK model:

$$\begin{aligned}
\tilde{p}_t &= \frac{K_t}{F_t},\ \tilde{p}_t \equiv \frac{\tilde{P}_t}{P_t},\ F_t = 1 + \beta\theta E_t \bar{\pi}_{t+1}^{\varepsilon-1} F_{t+1} \text{ (a)} \\
K_t &= \frac{\varepsilon}{\varepsilon - 1} s_t + \beta\theta E_t \bar{\pi}_{t+1}^{\varepsilon} K_{t+1} \text{ (b)} \\
\tilde{p}_t &= \left[\frac{1-\theta\bar{\pi}_t^{\varepsilon-1}}{1-\theta}\right]^{\frac{1}{1-\varepsilon}} \rightarrow \frac{K_t}{F_t} = \left[\frac{1-\theta\bar{\pi}_t^{\varepsilon-1}}{1-\theta}\right]^{\frac{1}{1-\varepsilon}} \quad \text{(c)} \\
s_t &= \frac{(1-\nu)\,\vartheta_t}{\exp(a_t)}
\end{aligned}$$

- Log-linearizing (a)-(c) around zero inflation steady state (and, assuming $1 - \nu = (\varepsilon - 1)/\varepsilon$)

$$\boxed{\begin{array}{l} \pi_t = \frac{(1-\theta)(1-\beta\theta)}{\theta}\hat{s}_t + \beta\pi_{t+1} \\ \hline \pi_t \equiv \bar{\pi}_t - 1. \end{array}}$$

Linearized Equilibrium Conditions for Households and Goods Producing Firms

- Equations

$$\boxed{\begin{array}{l} \pi_t = \frac{(1-\theta)(1-\beta\theta)}{\theta}\hat{s}_t + \beta\pi_{t+1} \\ \hline x_t = E_t x_{t+1} - E_t\left[r_t - \pi_{t+1} - r_t^*\right] \\ \hline r_t^* = -\log(\beta) + E_t\left[a_{t+1} - a_t\right]. \\ \hline \hat{s}_t = \hat{\vartheta}_t - a_t. \end{array}}$$

- If we also have a monetary policy rule, would have 5 equations in 6 variables:

$$\pi_t, \hat{s}_t, x_t, r_t, r_t^*, \hat{\vartheta}_t$$

- Like before, need one more equation, net.
  - Recall, in simple model with competitive labor markets, have $\vartheta_t = C_t l_t^{\varphi}$.
  - Net additional equation provided by labor market frictions.

Monetary Policy

- Taylor rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\alpha} \times \exp\left\{(1-\alpha)\left[\phi_\pi\left(\bar{\pi}_t - 1\right) + \phi_x \log\left(C_t/C\right)\right] - u_t\right\},$$

  where u_t is an *iid* (expansionary) policy shock.

- Parameters were set to the following (fairly conventional) values:

$$\alpha = 0.80,\ \phi_\pi = 1.5,\ \phi_x = 0.05.$$

Labor Market

- Labor market needs to deliver one more equation, net.
- Large number of identical and competitive firms; produce homogeneous output using only labor, l_t, for real price, ϑ_t.
- At the start of period t, a firm pays a fixed cost κ to meet a worker.
  - firm and worker bargain over the wage and if they agree, work begins immediately.
  - Match survives into period $t+1$ with fixed, exogenous probability ρ.

Alternating Offer Bargaining

- Firm opens bargaining with an offer.
  - Worker may reject the offer and make a counter offer.
  - Firm may reject the worker's counter and then counter that...
- Optimizing firm makes lowest opening offer that does not trigger worker rejection.
  - rejection wastes time and has other costs that cut into surplus.
  - requires that firm knows worker's counter-offer in case worker rejects.
  - but, what the worker would counter-offer depends on what it thinks would trigger a firm rejection.
  - and so on....
- In equilibrium, bargaining stops with firm's opening offer.
  - still, to determine what that offer is requires a bunch of computations.

Alternating Offer Bargaining

- We assume, solution to bargaining problem well approximated by stationary sequence: $w_t, w_t^l, w_t, w_t^l, w_t, ...$
- The worker can choose one of three responses to a firm's offer:

  1. Accept offer, w_t, begin work immediately. Worker utility V_t.
  2. Reject offer and terminate negotiations. Worker utility U_t.
  3. Reject offer with intention of proposing counteroffer.
     - With probability δ negotiations break down. Go to U_t.
     - Otherwise, make counteroffer w_t^l. Utility of this option is V_t^l.
- In practice (3) is preferred to (2).
- Optimization by firm leads to 'firm best response function':

$$\overbrace{V_t}^{\substack{\text{utility of worker who accepts} \\ \text{firm offer and goes to work}}} = \overbrace{\delta U_t + (1-\delta)\frac{1}{1+r}V_t^l}^{\substack{\text{utility of worker who rejects} \\ \text{firm offer and makes counteroffer}}}$$

Alternating Offer Bargaining

- Suppose worker makes a counteroffer.
- The firm can choose one of three responses:
  1. Accept offer, w_t^l, begin working immediately. Firm value J_t^l.
  2. Reject offer and terminate negotiations. Firm value *zero*.
  3. Reject offer with intention of proposing counteroffer
     – With probability δ negotiations break down. Go to *zero* value.
     – Otherwise, pay a cost γ and make counteroffer w_t. Firm value J_t.
- In practice (3) is preferred to (2).
- Optimization by worker leads to 'worker best response function':

$$\overbrace{J_t^l}^{\text{value of firm that accepts worker offer}} = \overbrace{\delta \times 0 + (1-\delta)\left[-\gamma + \frac{1}{1+r}J_t\right]}^{\text{value of firm that rejects worker offer and makes counteroffer}}$$

Alternating Offer Sharing Rule

- Out of equilibrium value functions:

$$V_t^l = V_t + w_t^l - w_t,\ J_t^l = J_t + w_t - w_t^l$$

- Bargaining equilibrium conditions:

$$\begin{aligned} J_t^l &= (1-\delta)\left[-\gamma + \frac{J_t}{1+r}\right] \\ V_t &= \delta U_t + (1-\delta)\frac{V_t^l}{1+r} \end{aligned}$$

Substituting out for J_t^l and V_t^l :

$$\begin{aligned} J_t + w_t - w_t^l &= (1-\delta)\left[-\gamma + \frac{1}{1+r}J_t\right] \\ V_t &= \delta U_t + (1-\delta)\frac{1}{1+r}\left(V_t + w_t^l - w_t\right) \end{aligned}$$

Alternating Offer Sharing Rule

- Substitute out $w_t - w_t^l$

$$
\begin{aligned}
J_t &= \frac{1+r}{1-\delta}\left[V_t - \alpha U_t - \omega\right] \\
\alpha &\equiv 1 - r\frac{(1-\delta)}{r+\delta},\ \omega \equiv \frac{(1-\delta)^2}{r+\delta}\gamma
\end{aligned}
$$

- Looks a lot like the Nash sharing rule:

$$
J_t = \frac{1-\eta}{\eta}\left[V_t - U_t\right],
$$

where η is the share of surplus going to workers.

14 Labor Market Equilibrium Conditions

13 new vbls: $l_t, x_t, Q_t, J_t, V_t, U_t, m_t, f_t, \Theta_t, Y_t, v_t, \bar{w}_t, p_t^*$

$$(1)\ l_t = (\rho + x_t)\, l_{t-1},\ (\mathbf{2})^+\ \kappa = J_t$$

$$(3)\ J_t = \vartheta_t - \bar{w}_t + \rho E_t m_{t+1} J_{t+1},\ (4)\ V_t = \bar{w}_t$$

$$+E_t m_{t+1}\left[\rho V_{t+1} + (1-\rho)\left(f_{t+1} V_{t+1} + (1 - f_{t+1})\, U_{t+1}\right)\right]$$

$$(5)\ U_t = D + E_t m_{t+1}\left[f_{t+1} V_{t+1} + (1 - f_{t+1})\, U_{t+1}\right]$$

$$(\mathbf{6})^+\ J_t = \frac{1+r}{1-\delta}\left[V_t - \alpha U_t - \omega\right],\ (7)\ Q_t = \sigma_m \Theta_t^{-\sigma},$$

$$(8)\ \Theta_t = \frac{l_{t-1} v_t}{1 - \rho l_{t-1}}, (9)\ m_{t+1} = \beta \frac{u'(C_{t+1})}{u'(C_t)},$$

$$(\mathbf{10})^+\ C_t + \kappa x_t l_{t-1} = Y_t,\ (11)\ f_t = \frac{x_t l_{t-1}}{1 - \rho l_{t-1}},\ (12)\ Y_t = p_t^* \exp(a_t)$$

$$(13)\ Q_t = \frac{x_t}{v_t},\ (14)\ \left(p_t^*\right)^{-1} = (1-\theta)\left(\frac{1 - \theta \bar{\pi}_t^{(\varepsilon-1)}}{1-\theta}\right)^{\frac{\varepsilon}{1-\varepsilon}} + \theta \frac{\bar{\pi}_t^{\varepsilon}}{p_{t-1}^*}$$

$^+$ Adjustments relative to DMP model with search.

Assigning Values to Parameters

- Shortage of one equation in goods and household sector.
- The labor market added, on net, one equation (i.e., 13 extra variables and 14 extra equations).
- The model has the following 12 parameters

$$\overbrace{\beta}^{\text{discount factor}}, \overbrace{\theta}^{\text{sticky price parameter}}, \overbrace{\varepsilon}^{\text{elasticity of demand}},$$

$$\overbrace{\rho_a, \sigma_a}^{\text{technology shock parameters}} \overbrace{D}^{\text{unemployment payment}}, \overbrace{\kappa}^{\text{cost of hiring}},$$

$$\overbrace{\sigma_m, \sigma}^{\text{matching function}}, \overbrace{r, \delta, \gamma}^{\text{bargaining parameters}}$$

- Parameter values of goods and household sector easy to choose, since there is a lot of experience with them
  - $\beta = 0.99$, $\rho_a = 0.95$, $\sigma_a = 0.01$, $\theta = 0.75$. Also, $1 + r = \beta^{-4/365}$.

Monetary Policy

- Taylor rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\alpha}$$
$$\times \exp\left\{(1-\alpha)\left[\phi_{\pi}\left(\bar{\pi}_t - 1\right) + \phi_x \log\left(C_t/C\right)\right] - u_t\right\},$$

  where u_t is an *iid* (expansionary) policy shock.

- Parameters were set to the following (fairly conventional) values:

$$\alpha = 0.70,\ \phi_{\pi} = 1.5,\ \phi_x = 0.05.$$

Calibration of Labor Market Parameters

With obvious adjustment, we adopt the DMP calibration:

Variable name	symbol	value
Endogenous Variables		
unemployment rate	$1-l$	0.055
replacement ratio	$\frac{D}{\bar{w}}$	0.4
search cost/gross output of homog good	$\kappa xl/Y$	0.01
vacancy filling rate	Q	0.7
Parameters		
elasticity of matching w.r.t. unemp	σ	0.5
discount factor	β	$1.03^{-0.25}$
match survival rate	ρ	0.9

Since we exogenously set the values of four endogenous variables, we must allow four exogenous parameters to be endogenous:

$$D, \kappa, \gamma, \sigma_m.$$

This leaves 1 free parameter, δ. In DMP model with search, no free parameter after calibration.

Steady state computations

First, go down first column, then go down second.
In each case, which equilibrium condition that is used is indicated.

$R = 1/\beta$ (intertemporal Euler)	$D = \left(\frac{D}{\bar{w}}\right) \times \bar{w}$
(9) $m = \beta$	(10) $C = l - \kappa x l$
(1) $x = 1 - \rho$	(4)-(5) $V - U = \frac{\bar{w} - D}{1 - \beta\rho(1-f)}$
(11) $f = \frac{xl}{1 - \rho l}$	(5) $U = \frac{D + \beta f (V - U)}{1 - \beta}$
(12) $Y = l$	(6) $\gamma = \left[V - \frac{1-\delta}{1+r} J - \alpha U\right] \frac{r+\delta}{(1-\delta)^2}$
$\kappa = (\kappa x l / Y) \times Y / (lx)$	(8) $\Theta = \frac{xl}{Q(1 - \rho l)}$
(2) $J = \kappa$	(7) $\sigma_m = Q\Theta^\sigma$
$\vartheta = 1$ (pricing equations)	(13) $v = x/Q$
(3) $\bar{w} = \vartheta + \rho\beta J - J$	

where

$$\alpha \equiv 1 - r\frac{(1-\delta)}{r+\delta}.$$

Given δ, can compute steady state of the model and also $D, \kappa, \gamma, \sigma_m$.

Assigning a Value to Probability of Breakdown

- Higher γ, more inertial is the wage.
- Higher δ, less inertial is the wage.
- In the calibration, γ varies with δ:

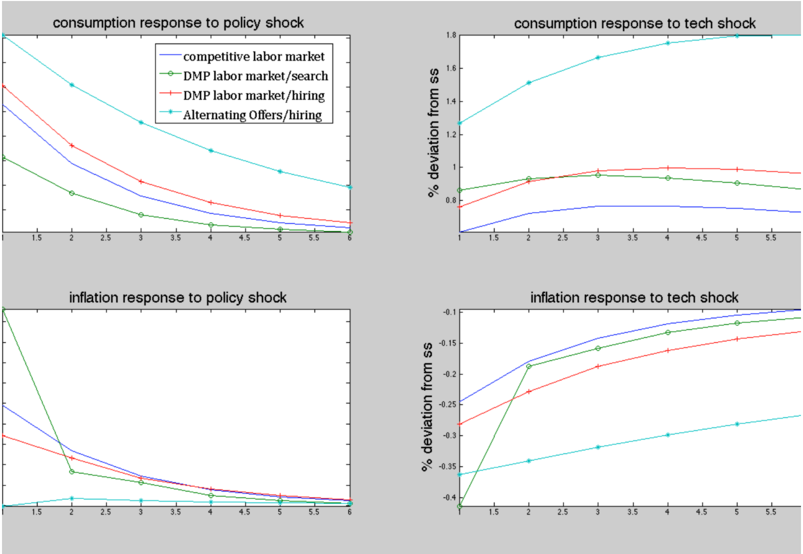
$$\frac{d\gamma}{d\delta} = J\frac{r+\delta}{(1-\delta)^2}\frac{1}{1+r} + \frac{\gamma}{r+\delta} + \frac{2\gamma}{1-\delta} > 0.$$

  Given calibration, not obvious what the effect of increasing δ is, since it is associated with a rise in γ.

- Adjust δ until the inflation effect of a monetary policy shock is close to zero.

$$\delta = 0.0075,\ D = 0.40,\ \sigma_m = 0.67,\ \gamma = 0.017$$

  – γ ~ cost, in terms of days of output per worker, to firm of a rejection $= 1.05$



consumption response to policy shock
competitive labor market
DMP labor market/search
DMP labor market/hiring
Alternating Offers/hiring
consumption response to tech shock
% deviation from ss
inflation response to policy shock
inflation response to tech shock
% deviation from ss

Intuition

- Policy shock drives real interest rate down.
  - Induces increase in demand for output of final good producers and therefore output of sticky price retailers.
  - Latter must satisfy demand, so retailers purchase more of wholesale good driving up its relative price.
  - Marginal revenue product (ϑ_t) associated with worker rises.
  - Wholesalers hire more workers, raising probability that unemployed worker finds a job.
- Workers' disagreement payoffs rise.
  - Increase in workers' bargaining power generates rise in real wage.
- Alternating offer bargaining mutes rise in real wage.
  - Allows for large increase in employment, substantial decline in unemployment, small rise in inflation.

Simple Macro Model Implications

- Our model is in principle capable of accounting for business cycle facts and the Shimer puzzle without exogenously sticky wages.

- Next, do a formal macro data analysis using medium-sized DSGE model.

Medium-Sized DSGE Model

- Standard empirical NK model (e.g., CEE, ACEL, SW).
  - Habit persistence in preferences.
  - Variable capital utilization.
  - Investment adjustment costs.
  - Calvo-sticky prices.
- Our labor market structure

Medium-Sized DSGE Model

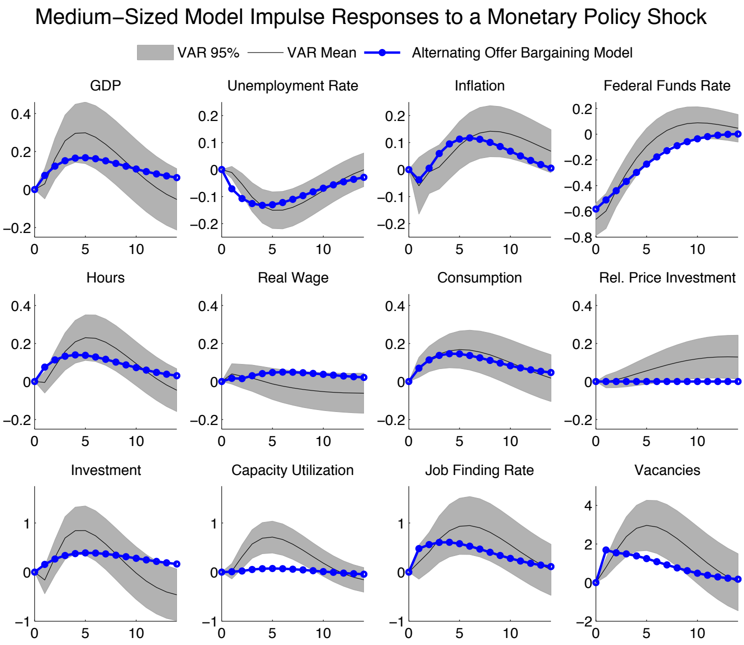
- Estimate VAR impulse responses of aggregate variables to a monetary policy shock and two types of technology shocks.
- 11 variables considered:
  - Macro variables and real wage, hours worked, unemployment, job finding rate, vacancies.
- Impulse-response matching by Bayesian methods.

Posterior Mode Of Key Parameters

- Prices change on average every 2.5 quarters (but, no indexation).
- δ : roughly 5% chance of a breakup after rejection.
- γ : cost to firm of preparing counteroffer is 2.5 days of production.
- Replacement ratio is 0.77.
  - Defensible based on micro data (Gertler-Sala-Trigari, Aguiar-Hurst-Karabarbounis).

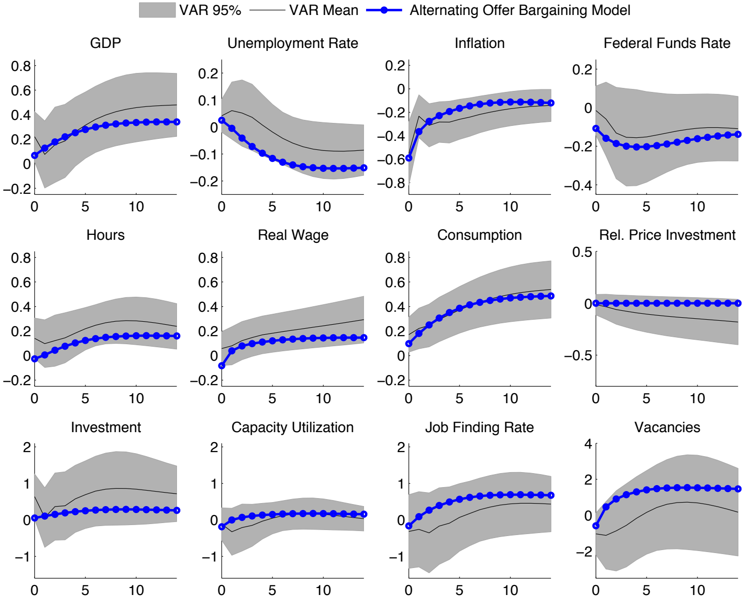
Model Comparison

- Marginal likelihood:
  - strongly prefers our model over:
    - standard DMP
    - NK sticky wage model with no wage indexation.
- Our model outperforms standard DMP setup in terms of plausibility of estimated parameters.
  - For example, estimated replacement ratio in standard DMP setup is 0.98.



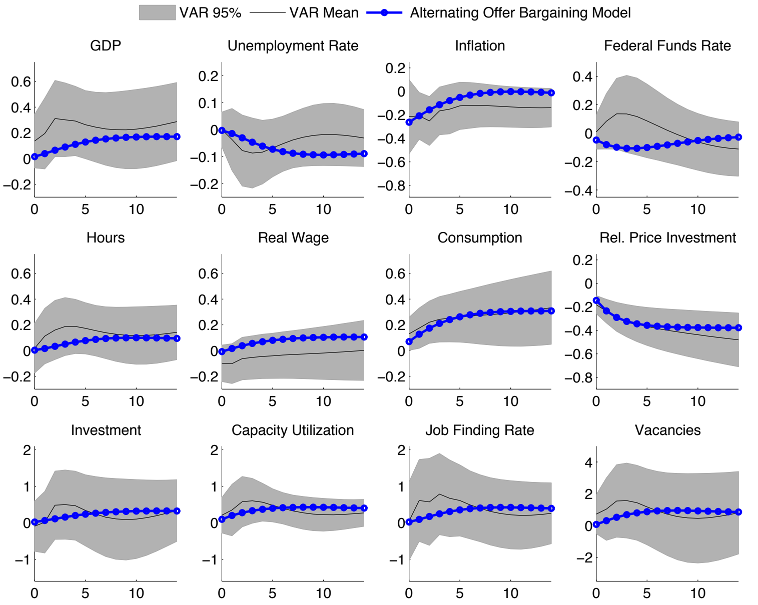
Notes: x−axis: quarters, y−axis: percent

Medium–Sized Model Impulse Responses to a Neutral Technology Shock



Notes: x–axis: quarters, y–axis: percent

Medium−Sized Model Responses to an Investment−specific Technology Shock



Notes: x−axis: quarters, y−axis: percent

Cyclicality of Unemployment and Vacancies

- Similar to Shimer (2005), we simulate our model subject to a stationary neutral technology shock only.

Standard Deviations of Data vs. Models

	$\frac{\sigma(\text{Labor market tightness})}{\sigma(\text{Labor productivity})}$
Data	27.6
Standard DMP Model	13.6
Our Model	33.5

Conclusion

- We constructed a model that is consistent with one estimate of the way the economy responds to various business cycle shocks.
- The key feature of our model:
  - Wages determined by alternating offer bargaining.
  - We do not assume any exogenous wage stickiness
- The model implies that nominal and real wages are inertial.
- Outstanding question:
  - Do the micro data support the position taken on bargaining here?