Unemployment and Business Cycles

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Background

- Key challenge for modern business cycle models.
  - How to account for observed volatility of labor market variables?

- Standard view
  - For plausibly parameterized models, in a boom, wages rise too rapidly, limiting expansion of employment.
  - Classic RBC models, standard efficiency wage models (Alexopolous), standard DMP models (Shimer).
Ongoing Efforts

• Empirical NK models more successful in accounting for cyclical properties of employment.

• Problems
  – Assume result: wages are exogenously sticky,
  – Agents wouldn’t choose this wage arrangement.
  – Limits class of experiments you can sensibly conduct.
  – Can’t use models to examine some key policy issues, e.g. extension of unemployment benefits.
  – Wages are always changing because of indexation.
What We Do

- Develop and estimate model that accounts for key business cycle properties of labor market.

- We derive wage inertia as an equilibrium outcome.

- Modified version of Hall-Milgrom (2008, HM):
  - When workers and firms bargain, they think they’re better off reaching agreement than parting ways.
  - Disagreement leads to continued negotiations.
  - If negotiation costs don’t depend sensitively on state of economy, neither do wages.

- We embed this source of inertia in an empirical, dynamic GE model.
Key Model Property

- After expansionary shock, rise in wages is relatively small.
  - Firms receive large share of rents associated with matches.
  - Firms have strong incentive to expand employment.

- Muted response of wages means firms’ marginal costs are relatively acyclical.
  - Allows model to account for inertial response of inflation with ‘sticky prices’ that are consistent with micro data.
Spot wages?

- In benchmark model, workers and firms bargain over wage rate in each period.

- Also consider approach where agents bargain over expected discounted value of wage payments.

- Two approaches lead to identical allocations, though possibly different spot wages.
  - Latter approach is consistent with nominal wage of given worker at a firm being constant for extended periods of time.
  - Wage changes only for new hires.
  - Volatility of wages of job changers can be different from those of incumbents.
Spot wages

- ‘Spot wage’ approach is useful benchmark for two reasons.
  - Let’s us easily incorporate wage data into our empirical analysis.
  - PV approach makes strong assumptions about agents’ ability to commit to stream of wage payments.
Comparisons

- Estimation strategy: Bayesian impulse response matching.
  - Standard macro variables, hours worked, real wages, unemployment, job findings and vacancies.

- Model outperforms standard DMP and sticky wage models.
  - Econometric measures of fit, plausibility of estimated structural parameters.
  - Estimated DMP has a replacement ratio well in excess of 0.90.
    - DMP model performance deteriorates dramatically with smaller replacement ratio.

- There’s just no need to work with sticky wage models anymore.
• Focus on ‘Shimer-type’ unconditional moments.
  – Example: labor market tightness is much more volatile than labor productivity.
  – Our model has no difficulty in accounting for this fact.

• There’s no Shimer puzzle in this environment.
Labor Market Model

- Large number of identical and competitive firms; produce homogeneous output using only labor, $l_t$.

- Firm pays fixed cost, $\kappa$, to meet a worker with probability 1 (GT, GST).

- In our empirical work we also consider a standard DMP setup where cost of meeting a worker is increasing function of labor market tightness.
Labor Market Model

- Worker and firm engage in alternating offer bargaining.
- Upon agreement, production begins immediately.
- Job continues in next period with probability, $\rho$. 
Value Functions

- $J_t$ is the value to a firm of an employed worker:

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

- $\vartheta_t$ and $m_{t+1}$ are determined in general equilibrium.

- Free entry and zero profits dictate:

$$\kappa = J_t.$$
Value Functions

- Value of employment to a worker:

\[ V_t = w_t + E_t m_{t+1} \left[ \rho V_{t+1} + (1 - \rho) (f_{t+1} \bar{V}_{t+1} + (1 - f_{t+1}) U_{t+1}) \right] \]

where \( f_{t+1} \bar{V}_{t+1} \) are job-to-job transitions, \( \bar{V}_{t+1} = V_{t+1} \) in equilibrium.

- Employment law of motion and job finding rate:

\[ l_t = (\rho + x_t) l_{t-1} \text{ and } f_t = \frac{x_t l_{t-1}}{1 - \rho l_{t-1}} \]

where \( x_t \) denotes the hiring rate.
Value Functions

- Value of unemployment to a worker:

\[ U_t = D + E_t m_{t+1} [f_{t+1} V_{t+1} + (1 - f_{t+1}) U_{t+1}] \]

where \( D \) denotes unemployment benefits.
Alternating Offer Bargaining

• Baseline specification:
  – Firms and workers bargain over current wage rate.
    • Each is entitled to reject an offer and either terminate negotiations or propose a counteroffer.
  – Agents take outcome of future wage bargains and economy-wide variables as given

• Bargaining occurs between two types of workers and firms
  – Those that just met for the first time.
  – Those that reached an agreement in previous period and match survived.
Alternating Offers

- Each quarter is divided into $M$ equal subperiods, $m = 1, .., M$.
  - Firm makes an opening wage offer in $m = 1$.
  - Worker can reject and make a counter offer in $m = 2$.
  - Firm can reject worker’s wage offer and make a new offer in next sub-period,...
  - If we get there because of rejections, worker makes a take-it-or-leave-it offer in last subperiod $M$.

- If an offer is accepted in any sub-period $m$, production begins immediately.
  - Value of production in any subperiod is $\vartheta_t / M$.

- Solution to the problem:
  $$w_t^1 (\equiv w_t), w_t^2, ..., w_t^M.$$
Firm’s Offer: round 1

- Firm offers $w_t^1$ as low as possible subject to worker not rejecting it.

- Optimization by firm leads to:

\[
V_t^1 = \delta U_t^1 + (1 - \delta) \left( \frac{D}{M} + V_t^2 \right)
\]

utility of worker who accepts firm offer and goes to work

utility of worker who rejects firm offer and intends to make counteroffer

where,

\[
V_t^1 \equiv w_t^1 + E_t m_{t+1} \left[ \rho V_{t+1} + (1 - \rho) \left( f_{t+1} \bar{V}_{t+1} + (1 - f_{t+1}) U_{t+1} \right) \right]
\]
Worker Offer: round 2

- Worker proposes highest possible wage $w^2_t$ subject to firm not rejecting it.

\[
\begin{align*}
\text{value of firm that accepts worker offer} & = J^2_t \\
\text{value of firm that rejects worker offer and intends to make counteroffer} & = \delta \times 0 + (1 - \delta) \left[ -\gamma + J^3_t \right]
\end{align*}
\]

- The firm incurs cost $\gamma$ to make a counter offer.

- Firm value:

\[
J^2_t \equiv \vartheta_t \frac{M - 1}{M} - w^2_t + \rho E_t m_{t+1} J_{t+1}
\]
Alternating Offers, Final Round

- Each bargaining round requires the wage for the next round.
- In the last round, the worker makes a final, take-it-or-leave-it-offer:

\[
J_t^M = \begin{cases} 
\text{value of firm that accepts worker offer in last round} \\
\text{value of firm that rejects worker's take-it-or-leave-it offer} 
\end{cases} = 0
\]

or

\[
J_t^M \equiv \frac{1}{M} \theta_t - w_t^M + \rho E_t m_{t+1} J_{t+1} = 0
\]
To determine \( w_t \equiv w^1_t \), firm first solves \( w^M_t, w^{M-1}_t, w^{M-2}_t, \ldots, w^2_t \).

- \( M \) equilibrium conditions for the \( M \) unknowns.
- Equations collapse into the following single equation:

\[
J_t = \beta_1 (V_t - U_t) - \beta_2 + \beta_3 (\vartheta_t - D),
\]

where the \( \beta_i \)'s are functions of \( M, \gamma \) and \( \delta \).

Note the constant terms that aren’t a function of the state of the economy.
Comparisons

- **Reduced Form Sharing Rule**
  \[ J_t = \beta_1 (V_t - U_t) - \beta_2 + \beta_3 (\vartheta_t - D) + \beta_5 U_t \]

- **Alternating Offer Sharing Rule**: \( \beta_5 = 0 \), \( \beta_i \)'s satisfy model restrictions. where the \( \beta_i \)'s are functions of \( M, \gamma \) and \( \delta \).
  - Testable special case of general sharing rule.

- In standard DMP setup, **Nash sharing rule**: \( \beta_1 = (1 - \eta) / \eta \), \( \beta_i = 0 \), for \( i = 2, 3, 4, 5 \).
  - Nash is a *testable* special case of our specification.

- **Generalized Wage-setting Rule**: \( w_t \) a linear function of period \( t \) state.
Alternating Offers in a Simple Macro Model

- Competitive final goods production: \( Y_t = \left[ \frac{1}{\lambda_f} \int_0^1 Y_{j,t}^\frac{1}{\lambda_f} dj \right]^{\lambda_f} \).

- \( j \)th input produced by monopolistic ‘retailers’:
  - Production: \( Y_{j,t} = \exp(a_t) h_{j,t} \).
    \[ a_t = \tau a_{t-1} + \epsilon_t \]
  - Homogenous good, \( h_{j,t} \), purchased in competitive markets for real price, \( \theta_t \).
  - 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.
A Simple Macro Model ...

- Representative household:

\[ E_0 \sum_{t=0}^{\infty} \beta^t \ln C_t \]

\[ P_tC_t + B_{t+1} \leq W_t l_t + P_tD (1 - l_t) + R_{t-1}B_t + T_t \]

- Calibration: values for parameters that are common to simple macro model, medium-sized DSGE model correspond to prior means for latter model.
Figure 2: Small Model Impulse Responses to a 0.1 Percent Technology Shock

- **Inflation rate (ABP)**
  - Baseline (solid blue)
  - Higher $\delta$ (dashed black)
  - Lower $\gamma$ (solid pink)
  - Lower $D$ (solid green)
  - Lower $M$ (dotted red)

- **Real consumption (%)**
  - $C=0.936$ (solid blue)
  - $C=0.974$ (dashed black)
  - $C=0.965$ (solid purple)
  - $C=0.951$ (solid green)
  - $C=0.988$ (dotted red)

- **Unemployment rate (p.p.)**
  - $u=0.055$ (solid blue)
  - $u=0.016$ (dashed black)
  - $u=0.026$ (solid pink)
  - $u=0.039$ (solid green)
  - $u=0.002$ (dotted red)

- **Real wage (%)**
  - $w=0.989$ (solid blue)
  - $w=0.989$ (dashed black)
  - $w=0.989$ (solid purple)
  - $w=0.989$ (solid green)
  - $w=0.989$ (dotted red)
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 ($\vartheta_t$) 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 Shimer puzzle without exogenously sticky wages.

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

- Standard empirical NK model (e.g., CEE, ACEL, SW).
  - Calvo price setting frictions, but no indexation
  - Habit persistence in preferences.
  - Variable capital utilization.
  - Investment adjustment costs.

- Our labor market structure
Estimated Medium-Sized DSGE Mode

• 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.

• Estimate model using Bayesian variant of CEE (2005) strategy:
  – Minimizes distance between dynamic response to three shocks in model, analog objects in the data.
  – Particular Bayesian strategy developed in Christiano, Trabandt and Walentin (2011).
Posterior Mode of Key Parameters

- Prices change on average every 2.4 quarters (no price indexation).

- $\delta$: roughly 0.30% chance of a breakup after rejection.

- $\gamma$: cost to firm of preparing counteroffer is 1/4 of a day’s worth of production.

- Posterior mode of hiring cost as a percent of total wages newly hired workers (depends on $\kappa$): 6.7%.
Posterior Mode of Key Parameters

- Replacement ratio is 0.67.
  - Defensible based on micro data (Gertler-Sala-Trigari, Aguiar-Hurst-Karabarbounis).

- Gertler, Sala and Trigari (2008): plausible range for replacement ratio is 0.4 to 0.7.
  - Lower bound based on studies of unemployment insurance benefits
  - Upper boundary takes into account informal sources of insurance.

- Home production sector reduces required replacement ratio (see CET 2014).
Medium–Sized Model Impulse Responses to a Monetary Policy Shock

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

VAR 95%  VAR Mean  Alternating Offer Bargaining Model
Medium-Sized Model Impulse Responses to a Neutral Technology Shock

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

VAR 95% VAR Mean Alternating Offer Bargaining Model
Medium-Sized Model Responses to an Investment-specific Technology Shock

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

VAR 95%  VAR Mean  Alternating Offer Bargaining Model
Comparison With Other Models

- Erceg, Henderson and Levin (2000, EHL) setup:
  - Wage setting subject to Calvo sticky wage frictions (no indexation)
  - Marginal likelihood strongly prefers our model over sticky wage by about 67 log points
    - stems from lots of stuff, particularly inflation response to monetary policy and neutral technology shocks
Comparison With Other Models...

- Standard Nash with Search costs (DMP setup):
  - Firm posts vacancies, $\nu_t$ and meets worker with probability $Q_t$ that depends on job market tightness.
  - Free entry and zero profit condition: $\kappa = Q_t J_t$.
  - Workers and firms split surplus using Nash-sharing rule:
    \[ J_t = \frac{1 - \eta}{\eta} [V_t - U_t] \]

- Also considered Standard Nash with Hiring Costs

- Marginal likelihood results:
  - Prefers our model over Nash with search (hiring) costs by 40 (20) log points.
Model Comparisons, cont’d

• Estimated parameter values for Nash models implausible.

• Posterior mode for replacement ratio:
  – Nash search model: 0.96
  – Nash hiring model: 0.90
Cyclicality of Unemployment and Vacancies

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

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<tr>
<th>Standard Deviations of Data vs. Models</th>
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<tbody>
<tr>
<td>$\sigma$ (Labor market tightness)</td>
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<td>$\sigma$ (Labor productivity)</td>
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<tr>
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<th>Data</th>
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<td>Standard DMP Model</td>
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<td>Our Model</td>
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- Estimated DMP models also do well here.
Conclusion

- We constructed a model that accounts for the economy’s response to various business cycle shocks.

- Our model implies that nominal and real wages are inertial.
  - Allows the model to account for weak response of inflation and strong responses of quantity variables to business cycle shocks.

- Model outperforms sticky wage (no-indexation) NK in terms of statistical fit.

- Given limitations of sticky wage model, there’s simply no need to work with it.