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?
 - Central issue going back to dawn of modern macro models, Lucas and Rapping (1969).
- Standard diagnosis
 - For plausibly parameterized models, in a boom, wages rise too rapidly, limiting expansion of employment.
 - Classic RBC models (Chetty), standard efficiency wage models (Alexopoulos), standard DMP models (Shimer).

Sticky Wages...

- New Keynesian DSGE models successful in matching time series data, including hours worked, employment and real wages.
 - but, they assume the result by positing that wages are exogenously sticky.
 - model provides no rationale for wage stickiness.
 - approach criticized on micro data grounds
 - good macro fit requires wage indexation, so that all wages change all the time.
 - but, in micro data individual wages constant for lengthy spells.
 - underlying 'monopoly power' theory of unemployment
 - on questionable empirical grounds (Christiano (2010))
 - does not contribute to contemporary policy discussions (e.g., effects of extending unemployment benefits).

What We Do

- Develop and estimate a model in which wage inertia is derived as an *equilibrium* outcome.
- Build on 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.
 - HM's key insight: if negotiation costs don't depend sensitively on state of economy, neither do wages.
- Our dynamic GE model embeds this source of wage inertia and accounts for key features of the business cycle.
- Sticky wages have been an essential (and, somewhat embarrassing) feature of business cycle models
 - they are no longer necessary.

Empirical Results

- Estimation strategy: Bayesian impulse response matching.
 - Shocks to monetary policy, neutral and investment-specific technology.
 - Our model performs well relative to this metric.
 - Outperforms standard alternatives.
- Alternative strategy: 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.
 - No Shimer puzzle.

Labor Market Model

- Large number of identical and competitive firms; produce homogeneous output using only labor, l_t .
- Firm pays fixed cost, κ , 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.

Value Functions

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

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

- ϑ_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:

 $V_t = w_t + E_t m_{t+1} \left[\rho V_{t+1} + (1 - \rho) \left(f_{t+1} V_{t+1} + (1 - f_{t+1}) U_{t+1} \right) \right].$ where $f_{t+1} V_{t+1}$ are job-to-job transitions

• Employment law of motion and job finding rate:

$$l_t = \left(
ho + x_t
ight) l_{t-1}$$
 and $f_t = rac{x_t l_{t-1}}{1 -
ho l_{t-1}}$

where x_t denotes the hiring *rate*.

Value Functions

• Value of unemployment to a worker:

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

where D denotes unemployment benefits.

Bargaining

- Baseline specification:
 - Each worker-firm pair bargains each period.
 - Bargain over current wage rate, taking outcome of future wage bargains given.
 - 'Period-by-Period Bargaining'.

Alternating Offers

- Each quarter is divided into M equal subperiods, m = 1, .., M.
 - Firm makes an opening wage offer in m = 1.
 - Worker may reject and make a counter offer in m = 2.
 - Firm may reject worker's wage offer and make a new offer in next sub-period,...
 - If there is a whole sequence 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 ϑ_t/M .
- Solution to the bargaining 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:

utility of worker who accepts
firm offer and goes to work
$$V_t^1$$
 = $\delta U_t^1 + (1 - \delta) \left(\frac{D}{M} + V_t^2\right)$

where,

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

Worker Offer: round 2

• Worker proposes highest possible wage w_t^2 subject to firm not rejecting it:



- The firm incurs cost γ to make a counter offer.
- Firm value:

 $I_{t}^{2} \equiv$

value of worker output in subperiods 2 to ${\cal M}$

$$\overline{\vartheta_t \frac{M-1}{M}} \qquad \qquad -w_t^2 + \rho E_t m_{t+1} J_{t+1}$$

Alternating Offers, Final Round

- Each bargaining round requires the wage for the next round.
- If they go to last round with no agreement, the worker makes a final, take-it-or-leave-it-offer:



Calculations

- To determine $w_t \equiv w_t^1$, firm first solves w_t^M , w_t^{M-1} , w_t^{M-2} , ..., w_t^2 .
- M equilibrium conditions for the M unknowns.
- Linearity of bargaining equilibrium conditions implies:
 - simple equation determines spot wage, w_t .

Alternative Bargaining Arrangements

- Alternative arrangement has workers and firms bargaining just once, when they first meet. Equilibrium allocations always the same.
 - negotiate over wage rates in each date and state of nature associated with the duration of their match.
 - they do not care about the precise pattern of wage payments, only the present discounted value (PV).
 - many patterns are possible, including the pattern in the period-by-period bargaining assumed in the paper.
 - one pattern: worker receives fixed nominal wage as long as he's with firm.
 - Wages of new hires more volatile than wages of incumbents.
- Key issue associated with PV bargaining: commitment.
 - no need to address these issues in period-by-period bargaining.

Alternating Offers in a Simple Macro Model

- Competitive final goods production: $Y_t = \begin{bmatrix} 1 \\ \int Y_{j,t}^{\frac{1}{\lambda_f}} dj \end{bmatrix}^{\lambda_f}$.
- *j*th input produced by monopolistic 'retailers':
 - Production: $Y_{jt} = \exp(a_t)h_{j,t}$.
 - 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'.

A Simple Macro Model ...

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• Representative household:

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

$$P_t C_t + B_{t+1} \leq W_t l_t + P_t D (1 - l_t) + R_{t-1} B_t + T_t$$

• Household SDF, $m_{t+1} = \beta C_t / C_{t+1}$.

A Simple Macro Model ...

• Key log-linearized equilibrium conditions:

$$\begin{split} \hat{C}_t &= E_t \left\{ \hat{C}_{t+1} - \left(\hat{R}_t - \pi_{t+1} \right) \right\}_{\text{real marginal cost}} \\ \pi_t &= \beta E_t \pi_{t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta} \left[\hat{\vartheta}_t - a_t \right] \\ \hat{C}\hat{C}_t + \kappa x l \left(\hat{x}_t + \hat{l}_{t-1} \right) &= Y \hat{Y}_t \\ \hat{R}_t &= \alpha \hat{R}_{t-1} + (1-\alpha) \left[\phi_\pi \pi_t + \phi_y \hat{l}_t \right] + \varepsilon_{R,t} \end{split}$$

Calibration/Parameterization

| Parameter | Value | Description | | | | | | | |
|---------------------|---------------------------------|---------------------------------------|--|--|--|--|--|--|--|
| Panel A: Parameters | | | | | | | | | |
| β | 1.03 ^{-0.25} | 1.03 ^{-0.25} Discount factor | | | | | | | |
| ξ | 0.66 | Calvo price stickiness | | | | | | | |
| λ_f | 1.2 | Price markup parameter | | | | | | | |
| ρ_R | 0.7 | Taylor rule: interest rate smoothing | | | | | | | |
| r_{π} | 1.7 | Taylor rule: inflation coefficient | | | | | | | |
| r_y | 0.1 | 1 Taylor rule: employment coefficient | | | | | | | |
| ŏ | 0.9 | Job survival probability | | | | | | | |
| δ | 0.005 | Prob. of bargaining session break-up | | | | | | | |
| M | 60 | Max bargaining rounds per quarter | | | | | | | |
| au | 0.95 Roots for AR(1) technology | | | | | | | | |
| | Panel B: Steady State Values | | | | | | | | |
| $400(\pi - 1)$ | 0 | Annual net inflation rate | | | | | | | |
| 1 | 0.945 | Employment | | | | | | | |
| кxl/Y | 0.01 | Hiring cost to output ratio | | | | | | | |
| D/w | 0.4 | Replacement ratio | | | | | | | |



Figure 1: Small Model Impulse Responses to a 25 ABP Monetary Policy Shock

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.

Alternating Offers: Intuition

- Wages are relatively insulated from general economic conditions.
- To gain some intuition, it's useful to see how bargaining parameters influence responsiveness of wage to general economic conditions.
- Consider bargaining session between worker and firm in partial equilibrium.
 - They take all variables outside their control as given.
- Consider bargaining session between a single worker and a single firm after a rise in U_t experienced idiosyncratically by that pair.

Intuition...

- Suppose we're in nonstochastic steady state.
 - All aggregate shocks are fixed at their unconditional means, aggregate variables are constant
 - Ongoing idiosyncratic uncertainty at the worker-firm level.

$$w_U \equiv \frac{d\log w}{d\log U} = \frac{U}{w}\frac{dw}{dU}$$

- *U* and *w* denote value of unemployment and equilibrium wage in non-stochastic steady state.
- Derivative treats rise in *U* as something experienced idiosyncratically by one worker-firm bargaining pair.

Lower Break-up Probability

- Consider extreme case where $\delta = 0$.
 - There's no chance that workers and firms are thrown to their outside option during negotiations.
 - Here the value of unemployment, *U*, doesn't enter directly into indifference conditions governing worker and firms offers.
 - So we don't expect the real wage to depend much on outside conditions (shocks).
- By continuity, larger values of δ raise importance of U in worker's disagreement payoff, make real wage more sensitive to shocks.



Figure 1: Small Model Impulse Responses to a 25 ABP Monetary Policy Shock

Lower Firm Negotiation Costs

- Decrease in γ raises disagreement payoff of the firm, putting worker in weaker bargaining position.
 - Other things equal, this leads to decrease in $w^i \colon dw^i/d\gamma > 0$
 - But decrease is same regardless of U^i , so dw^i/dU is independent of γ : $d(dw^i/dU) / \gamma = 0$.
 - $d(dw^i/d\gamma)/dU = 0$
- Effect of change in γ on elasticty w_U operates entirely through its effect on steady state U/w.

Lower Firm Negotiation Costs

- Zero profit condition of firms implies w is independent of γ .
 - Decrease in γ places downward pressure on all worker-firm pair wages.
 - Since equilibrium steady state w doesn't respond to γ , U must change to neutralize downward pressure on w.
 - Rise in U (lower steady state unemployment) places upward pressure on w increasing the worker's disagreement payoff and his bargaining power.
- So a fall in γ raises $d\log w/d\ln(U)$



Value of unemployment, U



Figure 1: Small Model Impulse Responses to a 25 ABP Monetary Policy Shock

Lower Unemployment Benefits

- Decrease in *D* lowers disagreement payoff of workers, putting firm in stronger bargaining position.
 - Other things equal, this leads to fall in w^i : $dw^i/dD>0$
 - But fall is same regardless of U^i , so $d(dw^i/dD)/dU = 0 \rightarrow d(dw^i/dU)/dD = 0$
- Effect of change in D on elasticity w_U operates entirely through its effect on steady state U/w.

Lower Unemployment Benefits

- Steady state U rises with fall in D.
- So fall in D raises $d \log w / d \ln(U)$
 - Increases response of wages, inflation to external shocks,
 - Decrease response of employment, unemployment to those shocks.



Value of unemployment, U



Figure 1: Small Model Impulse Responses to a 25 ABP Monetary Policy Shock

More possible bargaining rounds

• Consider extreme case where M is very large.

value of firm that accepts worker offer in last round

$$\widetilde{J_t^M} = \frac{1}{M}\vartheta_t - w_t^M + \rho E_t m_{t+1} J_{t+1} =$$

value of firm that rejects worker's take-it-or-leave-it offer

$$\widehat{0}$$

$$w_t^M = rac{1}{M} artheta_t +
ho \kappa E_t m_{t+1}$$

- Extreme case, of M = ∞, implies w^M_t would be roughly constant (interest rate doesn't move much).
- This insensitivity is inherited by $w_t^1 (\equiv w_t)$, w_t^2 , ..., w_t^M .
- More generally, we expect the real wage to be more sensitive to shocks when M is smaller.



Figure 1: Small Model Impulse Responses to a 25 ABP Monetary Policy Shock



Small Model Impulse Responses to a 0.1 Percent Technology Shock

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

- 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 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.
- 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 2.5 quarters.
- δ : roughly 0.26% chance of a breakup after rejection.
- γ : 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 output (depends on κ): 0.54% of GDP.

Posterior Mode of Key Parameters

- Replacement ratio is 0.62.
 - 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.



Medium-Sized Model Impulse Responses to a Monetary Policy Shock

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

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.
 - Retailers must satisfy demand, so they 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 limits rise in real wage.
 - Allows for large increase in employment, substantial decline in unemployment, small rise in inflation.



Medium-Sized Model Impulse Responses to a Neutral Technology Shock

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



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

Comparison With Two Other Models

- Standard DMP setup:
 - Firms post vacancies and meet workers probabilistically.
 - Workers and firms split surplus using a Nash-sharing rule.
- Standard New Keynesian sticky wage model following Erceg-Henderson-Levin (2000).
 - No wage indexation.
- Embed labor market models in CEE-style empirical model.
 - Calvo price rigidities, but no price indexation.

Model Comparisons

- Marginal likelihood:
 - strongly prefers our model over standard DMP and NK sticky wage models by about 24 and 54 log points, respectively.
- Also, other models have relatively extreme parameter estimates.
 - For example, standard DMP formulation (Nash-sharing plus search), posterior mode of replacement ratio is 0.97.

Cyclicality of Unemployment and Vacancies

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

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 |

• 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 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.

| | Paior | | | | | Postarior | | | | | | |
|--|----------------------|----------------|-------------------|-------------------|-------------------|-------------------|-------------------|-----------|--|--|--|--|
| | | 1 1101 | A 14 4 | | 1 OSC | | C4!-l- | | | | | |
| | | | Borg | ing Oner | INash | | Sticky Wage | | | | | |
| | | | Bargaining | | Sharing | | Wage Indexation: | | | | | |
| Model # | | | M. | M- | M. | M. | M- | 165 | | | | |
| moues # | | D Marrie Ct. J | Mada Ctal | Media Chil | Media Cha | M-J-C+J | M- J- C+ J | Mada Ctd | | | | |
| | | D,Mean,Stu | Mode,Sta | Mode,Std | Mode,Sta | Mode,Sta | Mode, Sta | Mode,Sta | | | | |
| Price Setting Parameters | | | | | | | | | | | | |
| Price Stickiness | ξ | B,0.66,0.15 | 0.58,0.03 | 0.64,0.04 | 0.70,0.02 | 0.74, 0.02 | 0.74,0.02 | 0.65,0.03 | | | | |
| Price Markup Parameter | λ | G,1.20,0.05 | 1.43,0.04 | 1.43,0.04 | 1.42,0.04 | 1.43,0.04 | 1.25,0.05 | 1.36,0.04 | | | | |
| Monetary Authority Parameters | | | | | | | | | | | | |
| Taylor Rule: Smoothing | ρ_R | B,0.70,0.15 | 0.86,0.01 | 0.86,0.01 | 0.84,0.01 | 0.84,0.01 | 0.78,0.01 | 0.86,0.01 | | | | |
| Taylor Rule: Inflation | r_{π} | G, 1.70, 0.15 | 1.36,0.11 | 1.39,0.12 | 1.37,0.12 | 1.39,0.12 | 2.09,0.15 | 1.48,0.13 | | | | |
| Taylor Rule: GDP | r_y | G,0.10,0.05 | 0.04 ,0.01 | 0.04 ,0.01 | 0.04 ,0.01 | 0.04 ,0.01 | 0.01 ,0.01 | 0.09,0.03 | | | | |
| | | I | Preferences as | nd Technolog | y | | | | | | | |
| Consumption Habit | b | B,0.50,0.15 | 0.83,0.01 | 0.83,0.01 | 0.82,0.01 | 0.82,0.01 | 0.70,0.02 | 0.76,0.02 | | | | |
| Capacity Util. Adj. Cost | σ_a | G, 0.50, 0.30 | 0.08,0.04 | 0.06,0.03 | 0.06,0.04 | 0.05,0.03 | 0.04 ,0.02 | 0.04,0.03 | | | | |
| Investment Adj. Cost | $S^{\prime\prime}$ | G,8.00,2.00 | 13.67,1.8 | 13.80,1.9 | 13.41,1.9 | 13.50,1.9 | 5.31,0.82 | 7.94,1.10 | | | | |
| Capital Share | α | B,0.33,0.03 | 0.24,0.02 | 0.24,0.02 | 0.25,0.02 | 0.25,0.02 | 0.32,0.02 | 0.29,0.02 | | | | |
| Techn. Diffusion g, ϕ, κ, γ | θ_i | B,0.50,0.20 | 0.01,0.01 | 0.02,0.01 | 0.01,0.01 | 0.01,0.01 | 0.04,0.02 | 0.02,0.01 | | | | |
| Technology Diffusion D | θ_D | B,0.50,0.20 | 0.74,0.15 | 0.66,0.19 | 0.12,0.03 | 0.10,0.02 | - | - | | | | |
| | | | Labor Marke | t Parameters | 1 | | | | | | | |
| Prob. of Barg. Breakup | 100δ | G,0.50,0.40 | 0.30,0.06 | 0.06,0.06 | - | - | - | - | | | | |
| Replacement Ratio | D/w | B,0.40,0.10 | 0.67,0.06 | 0.69,0.07 | 0.90,0.01 | 0.96,0.01 | - | - | | | | |
| Hiring-Search Cost/Y | sı | G,1.00,0.30 | 0.50,0.16 | 0.17,0.04 | 0.55,0.17 | 0.47,0.14 | - | - | | | | |
| Match. Function Param. | σ | B,0.50,0.10 | 0.56,0.03 | 0.52,0.04 | 0.56,0.03 | 0.50,0.04 | - | - | | | | |
| Inv. Labor Supply Elast. | ψ | G,1.00,0.25 | - | 2 | - | 2 | 0.89,0.20 | 2.19,0.33 | | | | |
| Shocks | | | | | | | | | | | | |
| Std. Monetary Policy | σ_R | G,0.65,0.05 | 0.60,0.03 | 0.62 ,0.03 | 0.62,0.03 | 0.62 ,0.03 | 0.64 ,0.04 | 0.62,0.03 | | | | |
| Std. Neutral Technology | $\sigma_{\mu_{\pm}}$ | G,0.10,0.05 | 0.14,0.01 | 0.14,0.02 | 0.17,0.01 | 0.17,0.02 | 0.31,0.02 | 0.25,0.02 | | | | |
| Std. Invest. Technology | σ_{Ψ} | G,0.10,0.05 | 0.11,0.02 | 0.11,0.02 | 0.11,0.02 | 0.11 ,0.02 | 0.15 ,0.02 | 0.14,0.02 | | | | |
| AR(1) Invest. Technology | ρ_{Ψ} | B,0.75,0.10 | 0.73,0.06 | 0.73,0.06 | 0.74,0.06 | 0.75,0.05 | 0.58,0.06 | 0.63,0.06 | | | | |
| Memo Items | | | | | | | | | | | | |
| Log Marg. Likelihood (Laplace, 12 Variables): | | | 302.0 | 291.5 | 279.3 | 263.5 | - | - | | | | |
| Log Marg. Likelihood (Laplace, 9 Variables ^b): | | | 328.2 | 319.1 | 301.1 | 290.3 | 260.9 | 324.5 | | | | |
| Post. Odds - $M_1 : M_i$, $i = 1,, 6$ (9 Variab.): | | 1:1 | 9e3:1 | 6e11:1 | 3e16:1 | 2e29:1 | 1:40.4 | | | | | |

Table 4: Priors and Posteriors of Parameters for the Medium-sized Model

Notes: s_l denotes the steady state hiring or search cost to gross output ratio (in percent). For model specifications where particular parameter values are not relevant, the entries in this table are blank.

^a Sticky wage model as in Erceg, Henderson and Levin (2000).

^b Common dataset across all models, i.e. when unemployment, vacancies and job finding rates are excluded.