Unemployment Crises

Nicolas Petrosky-Nadeau[1] Lu Zhang[2]

[1]FRB San Francisco
and Carnegie Mellon University

[2]The Ohio State University
and NBER

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The key messages

Matching function with congestion effects a good description of aggregate relation between unemployment and vacancies going back to the 1920s

Model calibrated to the mean and volatility of unemployment in the postwar sample generates high unemployment rates as in the Great Depression

Summary of Results

A matching function with congestion effects

Matching identity: $G = \underbrace{q \times V}_{\text{Filled vacancies}} = \underbrace{f \times U}_{\text{Hired Unemployed}}$

- f and q linked through $\theta = V/U$

Matching function $G(U, V)$: increasing and concave

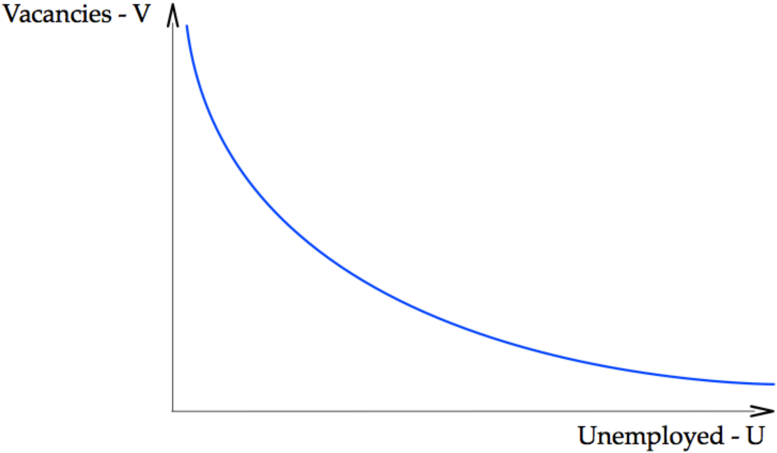
- Increasingly difficult to recruit workers when job seekers become scarce

Unemployment dynamics: $U_{t+1} - U_t = \underbrace{s(1 - U_t)}_{\text{Inflows}} - \underbrace{G(U_t, V_t)}_{\text{Outflows}}$

- Greater impact of vacancies on outflows when unemployment is high, i.e., $\frac{\partial G(U_t, V_t)}{\partial V_t}$ increasing in U_t

Matching, Congestion, and a Beveridge Curve

Steady state : $s(1 - U) = G(U, V)$



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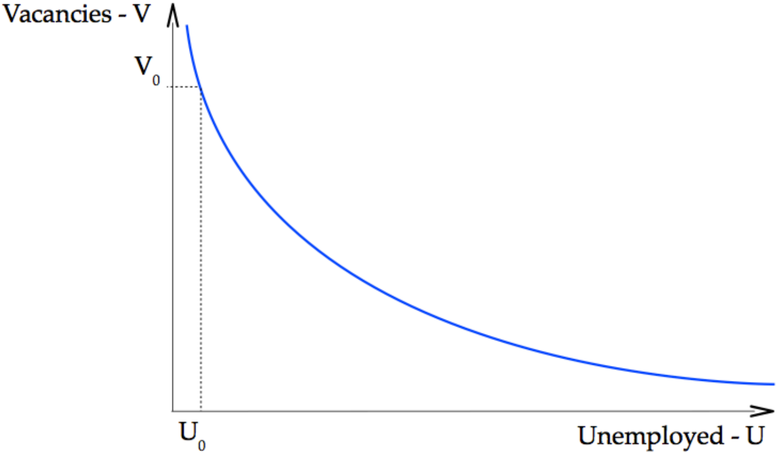

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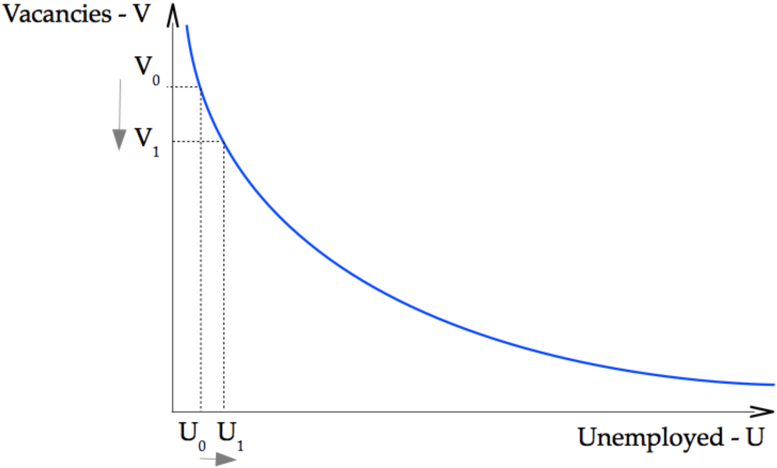

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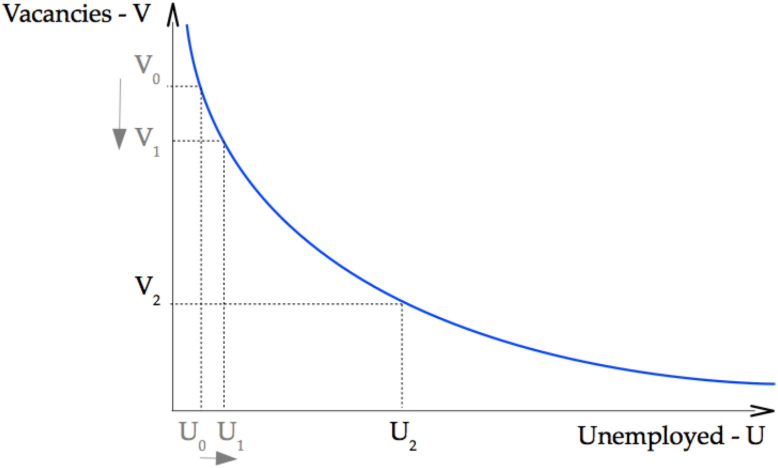

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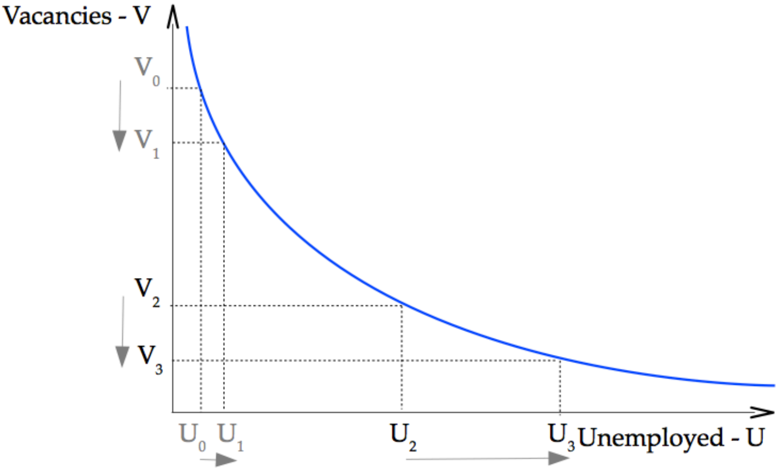
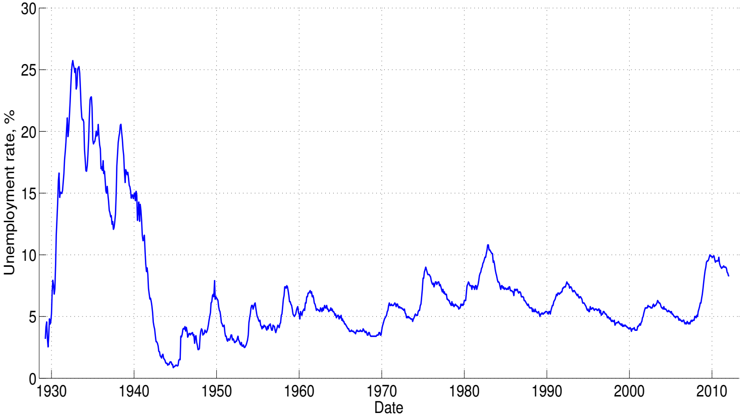


Facts

The monthly U.S. unemployment rate, 1929:4–2012:12



Data sources: NBER macro history files and BLS. U data details

Facts

Job vacancies and unemployment, 1929:04–2012:12

Construct a monthly job vacancy rate for U.S. starting 1929:04

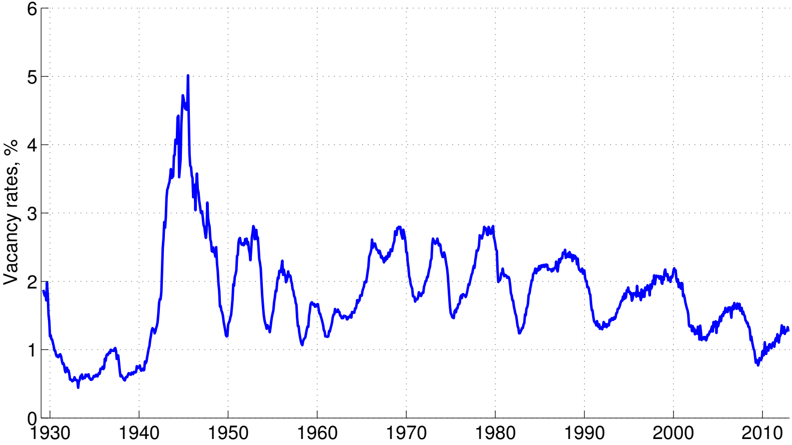
- Metropolitan Life Help-Wanted Index: 1919:01–1960:08
- Conference Board Help-Wanted Index: 1951:01–2006:07
- Barnichon's print and on-line Help-Wanted Index: 1995:01–2012:02
- Job Openings and Labor Turnover Survey: 2000:12–2012:12

Normalize by the size of the labor force and scale to a 2% average vacancy rate in 1965 (Abraham 1983, Zagorsky 1998)

HWI details

Facts

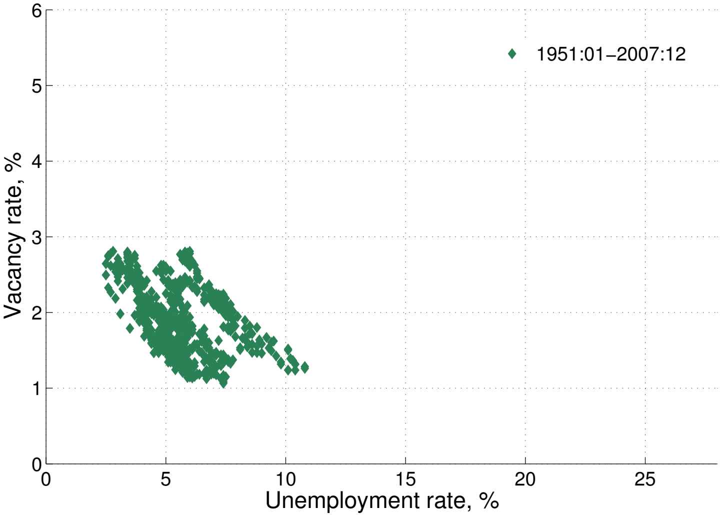
Monthly U.S. vacancy rate 1929:04–2012:12



Data sources: NBER macro history files, Barnichon (2010) and BLS.

Facts

U.S. Beveridge curve, 1929:04–2012:12



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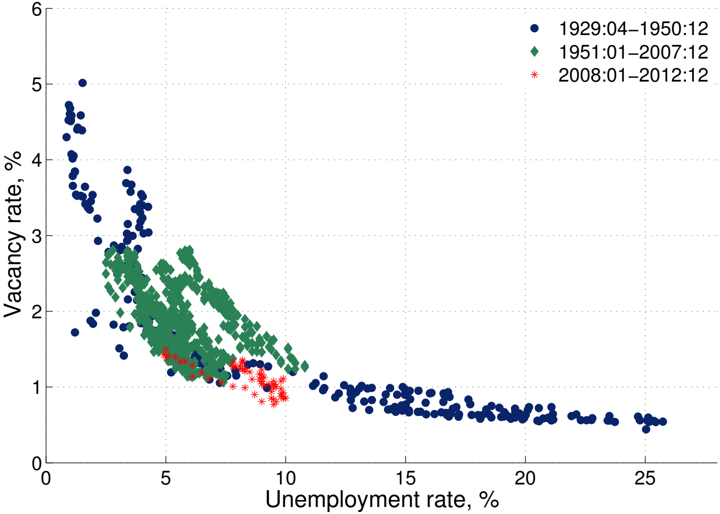


Matching, Congestion, and Unemployment Dynamics

Agnostic on structural driving forces as first pass:

- Fit AR(1) process on U.S. labor market tightness θ_t post-WWII

$$\log \theta_t = \omega + \rho_\theta \log \theta_{t-1} + \upsilon_t$$

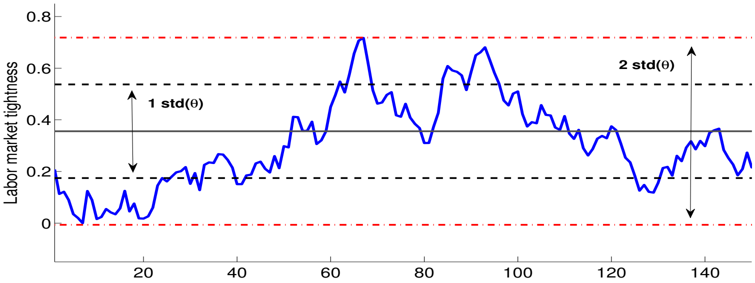
  - $\rho_\theta = 0.95$; $\omega = 0.016$

- Pass simulated θ_t through Cobb-Douglas matching function

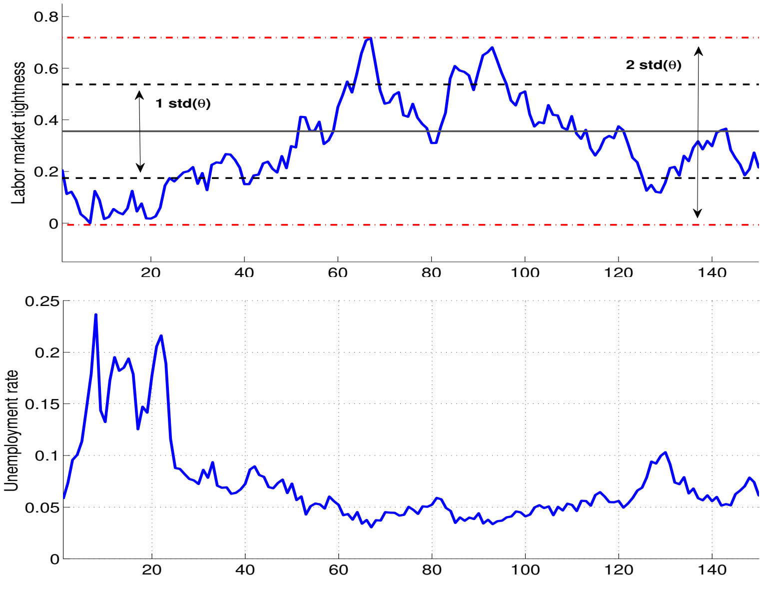
$$U_{t+1} - U_t = s(1 - U_t) - \chi U_t^\eta V_t^{1-\eta}$$

  - χ such that average unemployment = 5.8%
  - $\eta = 0.6$: mid range of estimates

Matching, Congestion, and Unemployment Dynamics



Matching, Congestion, and Unemployment Dynamics



Summary of Results

Unemployment crises

Model: Diamond-Mortensen-Pissarides with Hall-Milgrom wages

- 1 exogenous process: AR(1) labor productivity
- Calibrate to post-1951 U.S. data: mean (U) = 5.84%

		MODEL				U.S. DATA			
		U	V	θ	X	U	V	θ	X
		Non-crisis samples				1951:1–2012:12			
Volatility		0.102	0.191	0.274	0.13	0.131	0.142	0.269	0.013
Correlation	U		−0.732	−0.880	-0.742		−0.931	−0.981	−0.232
	V			0.966	0.950			0.984	0.391
	θ				0.938				0.925

Summary of Results

Unemployment crises

Congestion in matching generates important nonlinear dynamics

- Skewness, differences in steady states and stochastic means
- Do not use local perturbation methods
- Larger impulse responses when labor market is slack

Unemployment crises

- Occasionally high unemployment rate as in the Great Depression
- Large welfare costs of business cycle fluctuations

Representative large firm

- Post job vacancies, V_t, to attract unemployed workers, U_t
- Matching function CRS:

$$G(U_t, V_t) = \frac{U_t V_t}{(U_t^{\iota} + V_t^{\iota})^{1/\iota}}$$

- Job filling rate:

$$q(\theta_t) \equiv \frac{G(U_t, V_t)}{V_t} = \frac{1}{(1 + \theta_t^{\iota})^{1/\iota}}$$

in which $\theta_t = V_t / U_t$ is labor market tightness: $q'(\theta_t) < 0$

Model

The costs of job creation

Two types of job creation cost:

- Flow posting cost κ_0
- Fixed cost paid after hiring κ_1

Average cost to hiring a worker:

$$\frac{\kappa_0}{q(\theta_t)} + \kappa_0$$

Per period resources devoted to job creation:

$$\left[\kappa_0 + q(\theta_t)\kappa_1\right] V_t = \kappa_t V_t$$

- $\kappa_t \equiv \kappa_0 + q(\theta_t)\kappa_1$

Model

Law of motion for employment and production

Once matched, jobs are destroyed at a constant rate s:

$$N_{t+1} = (1 - s)N_t + q(\theta_t)V_t$$

Production technology:

$$Y_t = X_t N_t \quad \text{in which} \quad \log(X_{t+1}) = \rho \log(X_t) + \sigma\epsilon_{t+1}$$

The firm maximizes the market value of equity, S_t:

$$S_t = \max_{V_t} \{X_t N_t - W_t N_t - \kappa_t V_t + \beta E_t [S_{t+1}]\}$$

Subject to $$N_{t+1} = (1-s)N_t + q(\theta_t)V_t$$

in which W_t is the wage rate

Model

The intertemporal job creation condition

$$\underbrace{\frac{\kappa_t}{q(\theta_t)}}_{\text{Average cost}} = \underbrace{E_t\left[\beta\left[X_{t+1} - W_{t+1} + (1-s)\left[\frac{\kappa_{t+1}}{q(\theta_{t+1})}\right]\right]\right]}_{\text{Expected benefit}}$$

Response of equilibrium θ_t to productivity shocks:

- Benefit side: hinges on the equilibrium response of wage W
  - Implement credible wage bargaining, Hall-Milgrom (2008)
- Cost side: rigidity to changes in market tightness
  - $\kappa_t/q(\theta_t) = \kappa_0/q(\theta_t) + \kappa_1$ as in Pissarides (2009)

Model

Equilibrium

The goods market clearing condition:

$$C_t + \kappa_t V_t = X_t N_t$$

The recursive competitive equilibrium consists of vacancies, $V_t^\star$; and wages $W_t^\star$ and $W_t^{'\star}$:

- $V_t^\star$ satisfies the intertemporal job creation condition, while taking the wage equation as given
- $W_t^\star$ and $W_t^{'\star}$ satisfy the indifference conditions of the bargaining game
- The goods market clears

Computation

Projection with parameterized expectations a la Christiano and Fisher (2000)

Solve for:

1. $V(N_t, X_t)$
2. $W(N_t, x_t)$
3. $J_U(N_t, x_t), J_N^W(N_t, x_t)$, and $J_N^{W'}(N_t, x_t)$

From five functional equations:

1. A job creation condition
2. Wage offer to workers
3. Definitions of J_{Ut}, J_{Nt}^W and $J_{Nt}^{W'}$

Numerical Details

Calibration

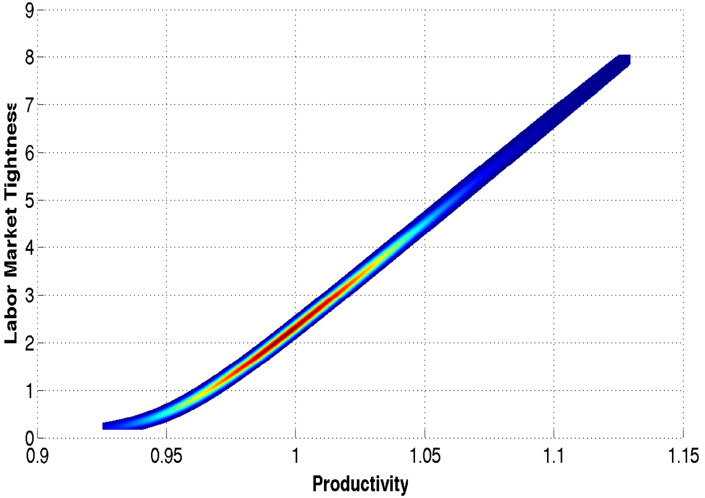
Monthly frequency

Notation	Parameter	Value
β	Time discount factor	$e^{-5.524/1200}$
ρ	Aggregate productivity persistence	$0.95^{1/3}$
σ	Conditional volatility of productivity shocks	0.00635
s	Job separation rate	0.045
ι	Elasticity of the matching function	1.25
b	The value of unemployment activities	0.71
δ	Probability of breakdown in bargaining	0.1
χ	Cost to employer of delaying in bargaining	0.25
κ_0	The proportional cost of vacancy posting	0.15
κ_1	The fixed cost of vacancy posting	0.2

- Simulate 50,000 artificial samples from the model, with 1,005 months in each sample
- Split the samples into two groups
  - Non-crisis samples - maximum unemployment rate $< 20\%$
  - Crisis samples - maximum rate is $\geq 20\%$

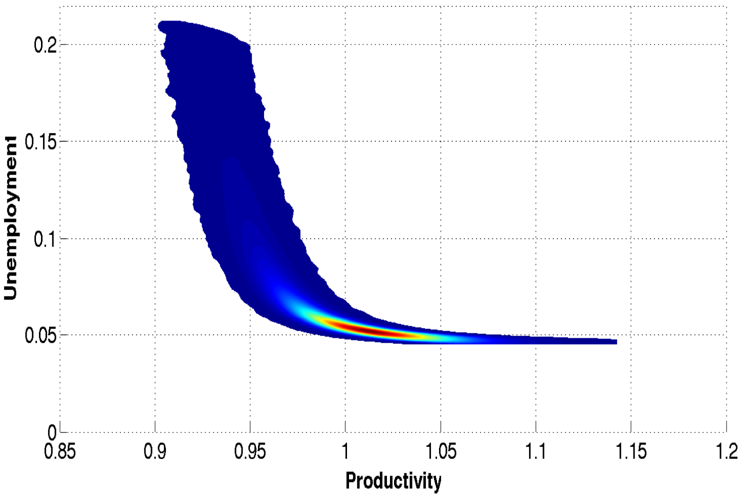
Properties: model's stationary distribution

Tightness θ: mean = 2.57; median = 2.49; 2.5 pctl = 0.40; 97.5 pctl = 5.15

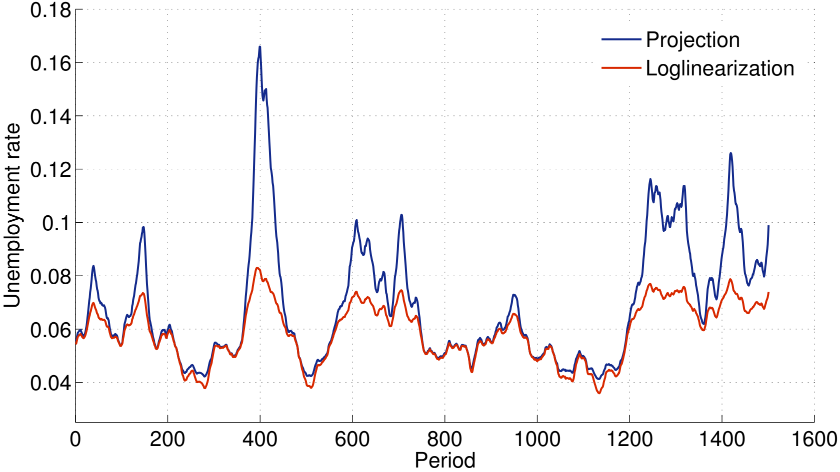


Properties: model's stationary distribution

Unemployment: mean = 5.84; median = 5.40; 2.5 pctl = 4.70; 97.5 pctl = 15.15



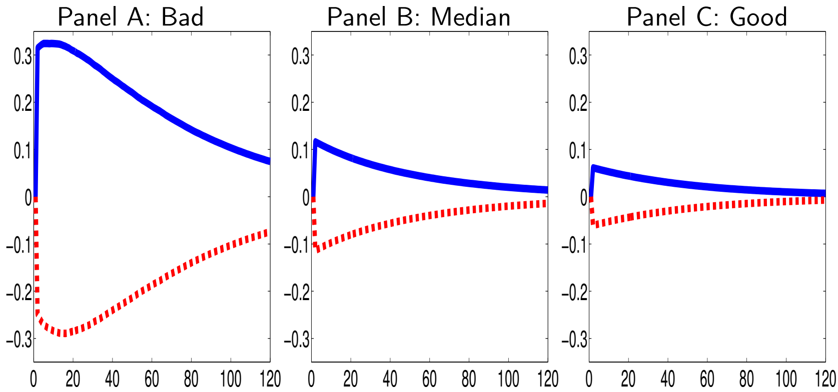
Projection vs. Loglinearization



See Petrosky-Nadeau and Zhang (2013), Solving the DMP model Accurately

Results

Nonlinear impulse response functions, θ_t

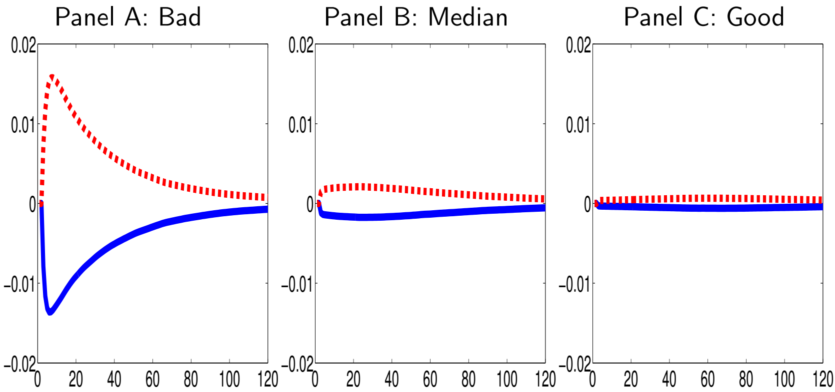


Bad ($U_t = 11.54\%$, $x_t = -0.0567$)
Median ($U_t = 5.40\%$, $x_t = 0$)
Good ($U_t = 4.75\%$, $x_t = 0.0564$)

Red: negative 1-σ shock
Blue: positive 1-σ shock

Results

Nonlinear impulse response functions, unemployment



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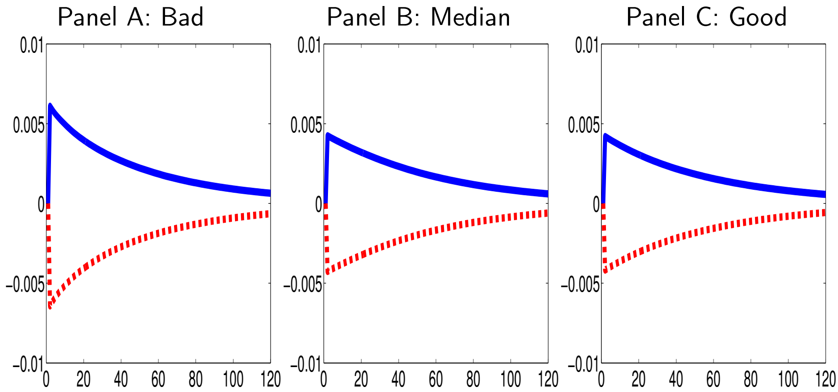
Results

Nonlinear impulse response functions, W_t



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Median ($U_t = 5.40\%$, $x_t = 0$)
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Red: negative 1-σ shock
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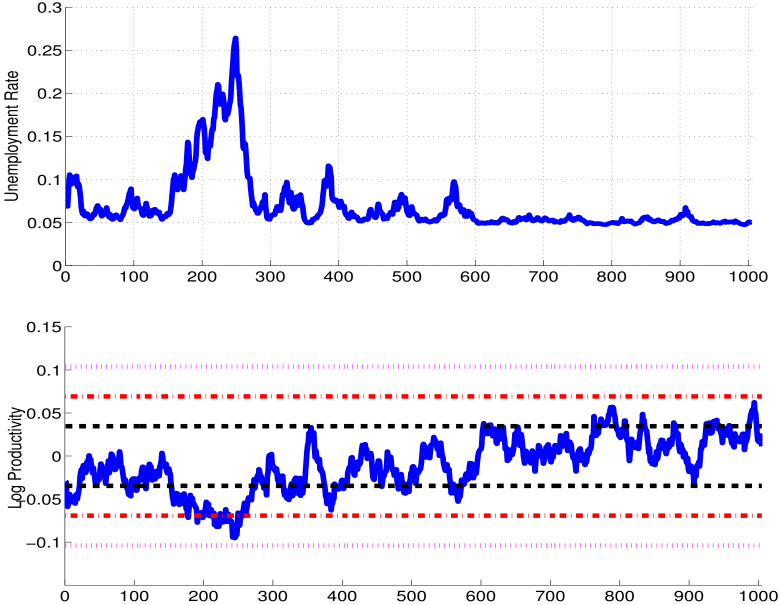
An illustrative crisis example



Results

Labor market volatilities in the model and data

		MODEL				U.S. DATA			
		U	V	θ	X	U	V	θ	X
		Non-crisis samples				1951:1–2012:12			
Volatility		0.102	0.191	0.274	0.13	0.131	0.142	0.269	0.013
Correlation	U		−0.732	−0.880	-0.742		−0.931	−0.981	−0.232
	V			0.966	0.950			0.984	0.391
	θ				0.938				0.925
		U	V	θ	X	U	V	θ	X
		Crisis samples				1929:4–2012:12			
Volatility		0.149	0.216	0.331	0.013	0.218	0168	0.368	
Correlation	U		−0.630	−0.861	−0.710		−0.827	−0.967	
	V			0.937	0.926			0.943	
	θ				0.925				

Facts

Aggregate state transition matrix in the data: Chatterjee and Corbae (2007)

Fit a three-state Markov chain model via maximum likelihood:

Economy evolves through good (g), bad (b), and crisis (c) states with different employment prospects

Transition matrix of the Markov chain be given by:

$$\Lambda = \begin{bmatrix} \lambda_{gg} & \lambda_{bg} & \lambda_{cg} \\ \lambda_{gb} & \lambda_{bb} & \lambda_{cb} \\ \lambda_{gc} & \lambda_{bc} & \lambda_{cc} \end{bmatrix}$$

- Good: $U \leq 5.70\%$
- Bad: $5.70\% < U \leq 20\%$
- Crisis: $U > 20\%$

Facts

Aggregate state transition matrix

Panel A: Data	Good	Bad	Crisis
Good	0.959	0.041	0
Bad	0.039	0.949	0.012
Crisis	0	0.177	0.824
Unconditional probability	0.468	0.497	0.035

Panel B: Model	Good	Bad	Crisis
Good	0.979	0.021	0
Bad	0.022	0.975	0.004
Crisis	0	0.157	0.842
Unconditional probability	0.494	0.473	0.032

- Good: $U \leq 5.70\%$
- Bad: $5.70\% < U \leq 20\%$
- Crisis: $U > 20\%$

Welfare Costs of Business Cycles

Lucas (1987): Negligible welfare cost of business cycles

Log utility with log-normal consumption growth:

- Willing to sacrifice only 0.008% of consumption in perpetuity to eliminate all aggregate fluctuations

Might be underestimated by overlooking:

- Crises in which the agent's marginal utility is high
- Steady state consumption higher than stochastic mean

Model with unemployment crises:

- 1.2%: 150 times the Lucas estimate
- Consumption: stochastic mean 0.95% lower than steady state

Conclusion

A search and matching model with credible bargaining reproduces the high unemployment as in the Great Depression

- Beveridge curve: complementarity of U and V in the matching function
- Credible bargaining: limited response of the wage to labor market conditions strengthens the crisis dynamics
- Policy and institutional shocks have greater effects on the labor market when it is slack

Computation

The five functional equations

$$\begin{aligned}
\frac{\kappa_t}{q(\theta_t)} - \lambda(N_t, x_t) &= \\
& E_t\left[\beta\left[X_{t+1} - W_{t+1} + (1-s)\left[\frac{\kappa_{t+1}}{q(\theta_{t+1})} - \lambda(N_{t+1}, x_{t+1})\right]\right]\right] \\
W(N_t, x_t) &= b + (1-\delta)\beta E_t\left[J_N^{W'}(N_{t+1}, x_{t+1}) - J_U(N_{t+1}, x_{t+1})\right] \\
& - (1 - s - \delta f_t)\,\beta E_t\left[J_N^{W}(N_{t+1}, x_{t+1}) - J_U(N_{t+1}, x_{t+1})\right] \\
J_U(N_t, x_t) &= \\
& b + E_t\left[\beta\left(f_t J_N^W(N_{t+1}, x_{t+1}) + (1-f_t) J_U(N_{t+1}, x_{t+1})\right)\right] \\
J_N^W(N_t, x_t) &= \\
& W_t + E_t\left[\beta\left((1-s) J_N^W(N_{t+1}, x_{t+1}) + s J_U(N_{t+1}, x_{t+1})\right)\right] \\
J_N^{W'}(N_t, x_t) &= \\
& W_t' + E_t\left[\beta\left((1-s) J_N^{W'}(N_{t+1}, x_{t+1}) + s J_U(N_{t+1}, x_{t+1})\right)\right]
\end{aligned}$$

Computation

Parameterized expectations a la Christiano and Fisher (2000)

Approximate the right-hand side of the Euler equation

$$\mathcal{E}(N_t, X_t) = E_t\left[\beta\left[X_{t+1} - W_{t+1} + (1-s)\left[\frac{\kappa_{t+1}}{q(\theta_{t+1})} - \lambda(N_{t+1}, x_{t+1})\right]\right]\right]$$

No need to parameterize λ_t separately

$$\frac{\kappa_t}{q(\theta_t)} - \lambda_t = \mathcal{E}_t$$

After obtaining $\mathcal{E}_t$, calculate $\tilde{q}(\theta_t) = \kappa_t/\mathcal{E}_t$

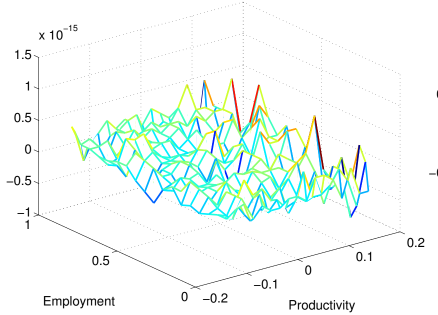
- If $\tilde{q}(\theta_t) \geq 1$ (binding constraint): $V_t = 0$, $\theta_t = 0$, $q(\theta_t) = 1$, and $\lambda_t = \kappa_t - \mathcal{E}_t$
- If $\tilde{q}(\theta_t) < 1$ (nonbinding constraint): $\lambda_t = 0$, $q(\theta_t) = \tilde{q}(\theta_t) \Rightarrow \theta_t = q^{-1}(\kappa_t/\mathcal{E}_t)$, $V_t = \theta_t(1 - N_t)$

Computation

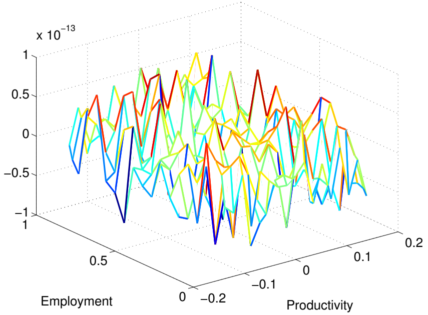
Solution method: Projection with parameterized expectations

- $\log(X_t)$ discretized with 17 grid points
- Cubic splines (20 basis functions) in N for each $\log(X)$-level

The $\mathcal{E}(N_t, x_t)$ error



The $W(N_t, x_t)$ error



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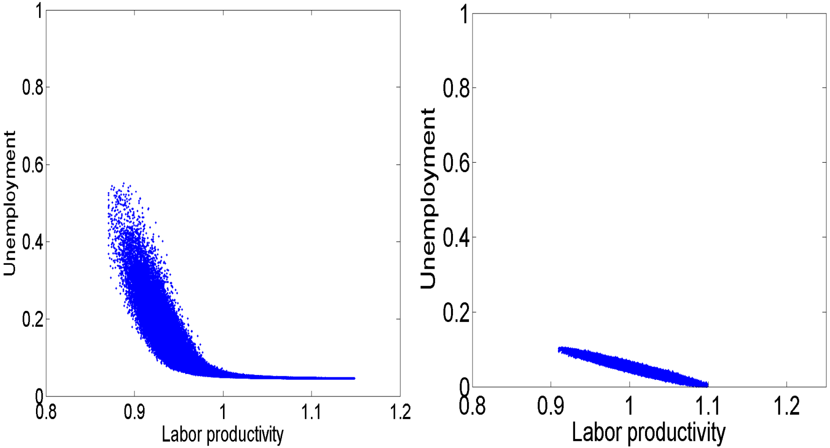
Linear Approximation

Petrosky-Nadeau and Zhang (2013): Solving DMP Accurately



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Data - Unemployment rate

Step 1

Construct monthly unemployment rate for U.S. starting 1929:04

- **April 1929 to February 1940** - National Industrial Conference Board, published by G. H. Moore Business Cycle Indicators, vol. II, p. 35 and p.123, from NBER data series m08292a
- **March 1940 to December 1946** - U.S. Bureau of the Census, Current Population Reports, Labor Force series P-50, no. 2, 13, and 19. From NBER data series m08292b.
- **January 1947 to December 1947** - use monthly (not S.A.) from January 1947 to December 1966 from Employment and Earnings and Monthly Report on the Labor Force, vol. 13, no. 9, March 1967 (NBER data series m08292c. Source:); apply X-12-ARIMA seasonal adjustment program from the U.S. Census Bureau; use S.A. series from January to December of 1947.
- **January 1948 to December 2012** - S.A. civilian unemployment rates from from Bureau of Labor Statistics (FRED series id: UNRATE)

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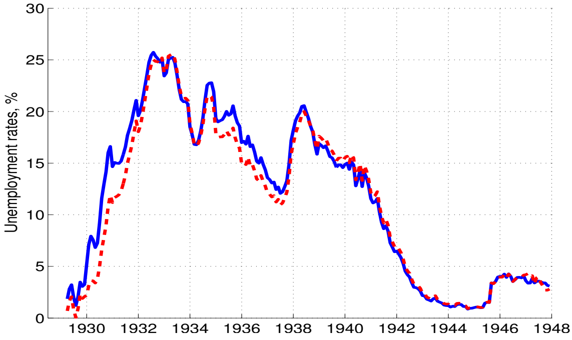
Data - Unemployment rate

Step 2

Adjust pre-1948 data as in Owyang, Ramey, and Zubairy (2013)

- Use the monthly unemployment rates from January 1930 to December 1947 to interpolate annual unemployment rates data from Weir (1992) using the Denton (1971) proportional interpolation procedure
- Scale the nine monthly rates from April to December 1929 so that their average matches the annual unemployment rate for 1929 reported in Weir.



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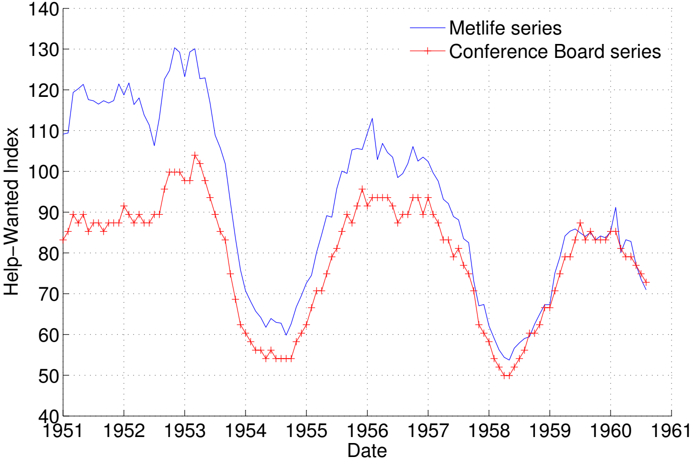
Data

Help-Wanted Index: MetLife and Conference Board



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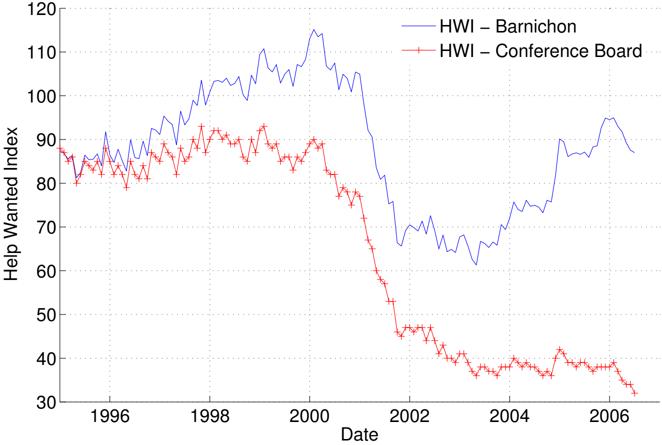
Data

Help-Wanted Index: Conference Board and Barnichon (2010)



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Model

Workers: employment and unemployment

Value of employment at a wage W_t

$$J^W_{Nt} = W_t + \beta E_t \left[(1-s) J^W_{Nt+1} + s J_{Ut+1} \right]$$

Value of unemployment:

$$J_{Ut} = b + \beta E_t \left[f_t J^W_{Nt+1} + (1-f_t) J_{Ut+1} \right]$$

- b: Unemployment flow value, forgone leisure
- s: Job separation rate
- f_t: Job finding rate

Model

Credible bargaining, Hall and Milgrom (2008)

Alternating wage offers leaving the other party just indifferent:

- Firm to worker: W_t

$$\underbrace{J_{Nt}^{W}}_{\text{Value of accepting offer}} = \underbrace{\delta J_{Ut} + (1-\delta)\left(b + E_t[\beta J_{Nt+1}^{W'}]\right)}_{\text{Value of refusing in order to make counteroffer}}$$

b: Unemployment flow value; δ: Breakdown probability; χ: Cost of delay

Model

Credible bargaining, Hall and Milgrom (2008)

Alternating wage offers leaving the other party just indifferent:

- Firm to worker: W_t

$$\underbrace{J_{Nt}^{W}}_{\text{Value of accepting offer}} = \underbrace{\delta J_{Ut} + (1-\delta)\left(b + E_t[\beta J_{Nt+1}^{W'}]\right)}_{\text{Value of refusing in order to make counteroffer}}$$

- Worker to firm: W_t'

$$S_{Nt}^{W'} = \delta \times 0 + (1-\delta)\left(-\chi + E_t[\beta S_{Nt+1}^{W}]\right)$$

b: Unemployment flow value; δ: Breakdown probability; χ: Cost of delay

Model

Assume the firm makes the first offer: W_t is the equilibrium wage

- Firm to worker: W_t

$$W_t = b - (1-s)\,\beta E_t\left[J^{W}_{Nt+1} - J_{Ut+1}\right] + \delta f_t \beta E_t\left[J^{W}_{Nt+1} - J_{Ut+1}\right] + (1-\delta)\beta E_t\left[J^{W'}_{Nt+1} - J_{Ut+1}\right]$$

- Worker to firm: W'_t

$$W'_t = X_t + \beta E_t\left[(1-s)S^{W'}_{Nt+1}\right] + (1-\delta)\left[\chi - \beta E_t S^{W}_{Nt+1}\right]$$

b: Unemployment flow value; δ: Breakdown probability; χ: Cost of delay

Model

Credible bargaining wage W_t: Polar cases $\delta = 1$ and $\delta = 0$

- $\delta = 1 \rightarrow$ Nash Bargaining wage set

$$W_t = b - (1 - s)\,\beta E_t\left[J^W_{Nt+1} - J_{Ut+1}\right] + f_t \beta E_t\left[J^W_{Nt+1} - J_{Ut+1}\right] + 0 \times \beta E_t\left[J^{W'}_{Nt+1} - J_{Ut+1}\right]$$

- $\delta = 0 \rightarrow$ Limited influence of labor market conditions

$$W_t = b - (1 - s)\,\beta E_t\left[J^W_{Nt+1} - J_{Ut+1}\right] + 0 \times f_t \beta E_t\left[J^W_{Nt+1} - J_{Ut+1}\right] + 1 \times \beta E_t\left[J^{W'}_{Nt+1} - J_{Ut+1}\right]$$

b: Unemployment flow value; δ: Breakdown probability; χ: Cost of delay;

Results

Comparative statics, labor market volatilities

	U	V	θ	X		U	V	θ	X
	Non-crisis samples					Crisis samples			
	$\delta = 0.15$								
Volatility	0.070	0.150	0.209	0.013		0.106	0.162	0.245	0.014
Autocorrelation	0.792	0.708	0.772	0.775		0.849	0.686	0.791	0.785
Correlation		−0.781	−0.895	−0.792	U		−0.650	−0.863	−0.735
			0.977	0.970	V			0.944	0.950
				0.960	θ				0.949
	$\chi = 0.2$								
Volatility	0.032	0.128	0.155	0.013		0.108	0.173	0.253	0.014
Autocorrelation	0.763	0.747	0.769	0.775		0.855	0.709	0.803	0.786
Correlation		−0.847	−0.901	−0.776	U		−0.596	−0.834	−0.502
			0.993	0.968	V			0.939	0.883
				0.951	θ				0.819

Results

Comparative statics, unemployment crises

	Good	Bad	Crisis	Good	Bad	Crisis
	$\delta = 0.15$ (% crisis samples = 1.85)			$\chi = 0.2$ (% crisis samples = 1.54)		
Good	0.9807	0.0193	0	0.9801	0.0199	0
Bad	0.0197	0.9780	0.0023	0.0199	0.9779	0.0023
Crisis	0	0.2127	0.7873	0	0.2660	0.7340
Uncond. prob.	0.4946	0.4852	0.0201	0.4901	0.4929	0.0170

Back

Results

Welfare cost of business cycles: Definition

Permanent percentage of the consumption flow C_t that the household would sacrifice to eliminate aggregate fluctuations:

$$E_t \left[\sum_{\triangle t=0}^{\infty} \beta^{\triangle t} \log \left[(1+\psi_t) C_{t+\triangle t} \right] \right] = \sum_{\triangle t=0}^{\infty} \beta^{\triangle t} \log \left(C^{\star} \right)$$

- $C^{\star}$: aggregate consumption at the deterministic steady state

The welfare cost is 1.2%, which is 150 times of the Lucas estimate

The stochastic mean is 0.95% lower than the steady state consumption