

Understanding the Great Recession

Lawrence Christiano Martin Eichenbaum Mathias Trabandt

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The Great Recession and its Aftermath

- Great Recession: extraordinary contractions in output, investment and consumption.
 - CET (2014), Hall (2014): cumulative loss of real GDP relative to its projected trend in 2007 is over 65% of 2007 real GDP.
- Per capita employment, LFPR dropped substantially, little sign of improving.
 - Unemployment rate declined from its peak.
 - But, decline primarily reflects drop in LFPR
 - While vacancies have risen to pre-recession levels, this rise hasn't translated into higher employment.
- Despite all this economic weakness, decline in inflation relatively modest.

Questions

- What were the key forces driving U.S. economy during the Great Recession?
- Mismatch in the labor market?
- Why was the drop in inflation so moderate?

To answer our questions we need a model

- Model must provide empirically plausible account of key macroeconomic aggregates
 - employment, vacancies, LFPR, job finding rate, unemployment rate, real wages
 - output, consumption, investment, ..
- Novel features of labor market
 - Endogenize labor force participation.
 - Derive wage inertia as an equilibrium outcome.
- Estimate model using pre-2008 data.
- Use estimated model to analyze post-2008 data.

Questions and Answers

- What forces drove real quantities in the Great Recession?
 - Shocks to financial markets were the key drivers, even for variables like labor force participation.
- *Consumption wedge*
 - motivated by literature stressing reduction in consumption as trigger for ZLB
 - perturbation to agents' intertemporal Euler equation governing accumulation of risk-free asset.
- *Financial wedge*
 - motivated by sharp increase in credit spreads observed in post-2008 period.
 - perturbation to households' first order condition for optimal capital accumulation.

Questions and Answers

- Mismatch in the labor market?
 - Not a first order feature of the Great Recession.
 - We account for 'shift' in the Beveridge curve, without resorting to structural shifts in the labor market.
- Rise in government consumption associated with ARRA had peak multiplier effect in excess of 2.
- But overall effect was small because of size and timing of spending.

Questions and Answers

- Why was the drop in inflation so moderate?
 - Prolonged slowdown in TFP growth during the Great Recession.
 - Rise in cost of firms' working capital as measured by spread between corporate-borrowing rate, risk-free interest rate.
- These forces drove up firms' marginal costs.
 - Exerted countervailing pressures on deflationary forces operative during post-2008 period

Labor Market

- Large number of identical households, with unit measure of members.
- Three types of activities:
 - $(1 - L_t)$ people in home production, not in labor force.
 - l_t people are in labor force and employed.
 - $(L_t - l_t)$ people unemployed, i.e. they're in labor force but don't have a job.

Labor Force Dynamics

- At end of each period, $1 - \rho$ percent of employed workers are separated from firm.
 - So at end of period $t - 1$, $(1 - \rho)l_{t-1}$ workers separate from firms, ρl_{t-1} workers remain attached to their firm
- Let u_{t-1} denote unemployment rate at end of $t - 1$.
- Sum of separated and unemployed workers is given by:

$$\begin{aligned}(1 - \rho)l_{t-1} + u_{t-1}L_{t-1} &= (1 - \rho)l_{t-1} + \frac{L_{t-1} - l_{t-1}}{L_{t-1}}L_{t-1} \\ &= L_{t-1} - \rho l_{t-1}.\end{aligned}$$

Labor Force Dynamics

- Separated, unemployed worker have equal probability, $1 - s$, of exiting labor force.
- So $s(L_{t-1} - \rho l_{t-1})$ remain in labor force, search for work.
- Household chooses r_t , number of workers that it transfers from non-participation into labor force.

- Labor force in period t is:

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

– By its choice of r_t household in effect chooses L_t .

- e_t : rate at which workers transit from non-participation to being in labor force

$$e_t = \frac{r_t}{1 - L_{t-1}}$$

Labor Force Dynamics

- Law of motion for employment is:

$$l_t = (\rho + x_t) l_{t-1}.$$

where x_t is hiring rate.

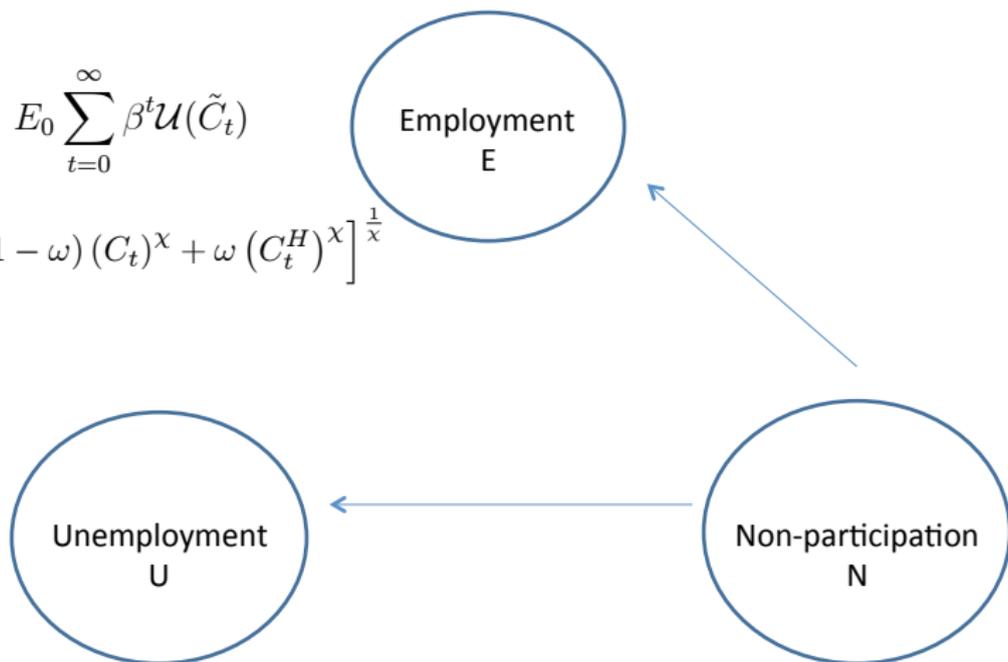
- Job finding rate: ratio of number of new hires divided by number of people searching for work

$$f_t = \frac{x_t l_{t-1}}{L_t - \rho l_{t-1}}.$$

Labor Market

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

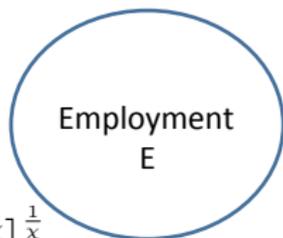
$$\tilde{C}_t = \left[(1 - \omega) (C_t)^x + \omega (C_t^H)^x \right]^{\frac{1}{x}}$$



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

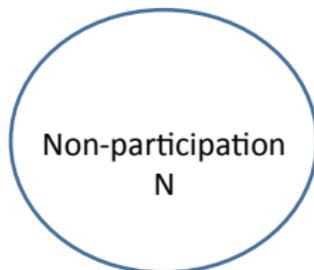
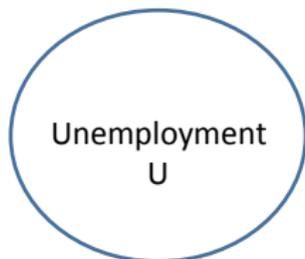
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$$C_t^H = (1 - L_t)^{1 - \alpha_c} (L_t - l_t)^{\alpha_c}$$



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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

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

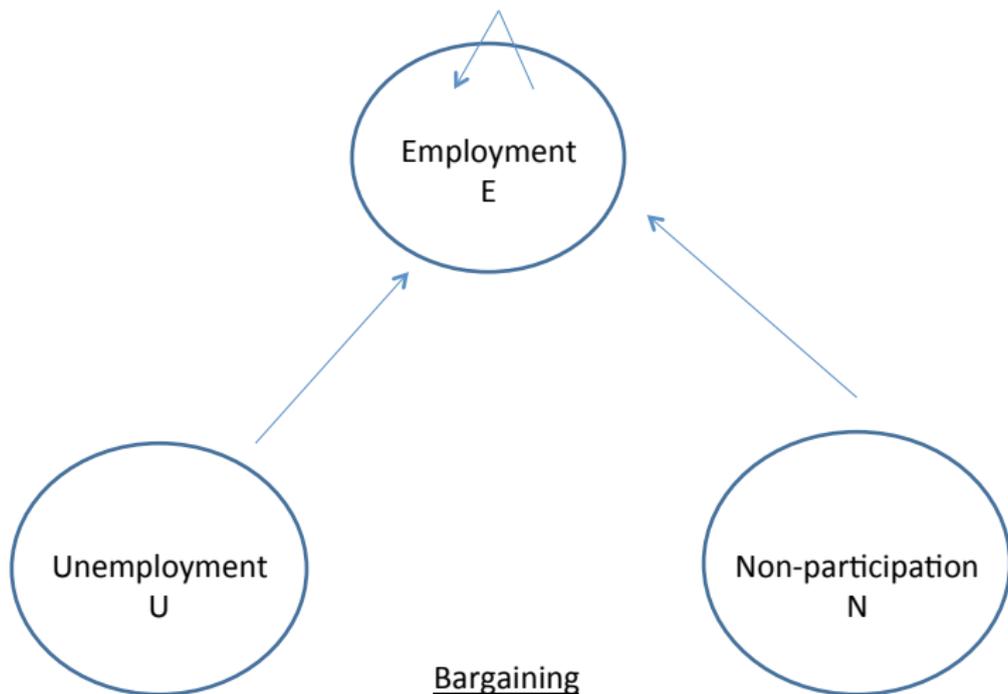
$$K_{t+1} = (1 - \delta_K) K_t + [1 - S(I_t/I_{t-1})] I_t$$

Unemployment
U

Non-participation
N

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

Labor Market



Bargaining

Three types of worker-firm meetings:

i) E to E , ii) U to E, iii) N to E

Modified version of Hall-Milgrom

- Firms pay a fixed cost to meet a worker.
- Then, workers and firms bargain.
 - Better off reaching agreement than parting ways.
 - Disagreement leads to continued negotiations.
- If bargaining costs don't depend sensitively on state of economy, neither will wages.
- After expansionary shock, rise in wages is relatively small.
 - See CET (2013), for intuition in a DSGE model with capital.

Modified version of Hall-Milgrom

- Bargaining protocol:
 - Day 1: firm makes opening offer. Worker can accept, reject and walk away or make counteroffer.
 - Day 2: worker makes counteroffer in case he rejected on first day. Firm can accept, reject and walk away or make counteroffer.
 - Day 3: firm makes counteroffer in case it rejected worker's counter offer...
 - Last day: worker makes take-it-or-leave-it offer.
- Opening offer is accepted.

Modified version of Hall-Milgrom

- Bargaining costs:
 - Direct cost of γ to firm of rejecting worker offer and preparing a counteroffer.
 - Rejection risks total break down in negotiations with probability δ .
 - Each day that negotiations continue means firm loses production for that day and worker loses wage.

Value Functions (abstract from growth)

- 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:

$$V_t = w_t + E_t m_{t+1} \left[\begin{array}{c} \rho V_{t+1} + (1 - \rho) s \left(\frac{f_{t+1} V_{t+1} + U_{t+1}}{(1 - f_{t+1})} \right) \\ (1 - \rho)(1 - s) N_{t+1} \end{array} \right].$$

- $f_{t+1} V_{t+1}$ are job-to-job transitions, N_{t+1} is value of being out of labor force.

Value Functions

- Value of unemployment to a worker:

$$U_t = D + E_t m_{t+1} \left[\begin{array}{c} s f_{t+1} V_{t+1} + s(1 - f_{t+1}) U_{t+1} \\ + (1 - s) N_{t+1} \end{array} \right].$$

where D denotes unemployment benefits.

- Value of non-participation

$$N_t = E_t m_{t+1} [e_{t+1} (f_{t+1} V_{t+1} + (1 - f_{t+1}) U_{t+1}) + (1 - e_{t+1}) N_{t+1}]$$

where e_t is probability of being selected to join labor force.

Medium-Sized DSGE Model

- Habit persistence in preferences
- Variable capital utilization.
- Adjustment costs.
 - Investment
 - Number of people in home sector.
- Taylor rule: inflation relative to target, output relative to growth path, year-to-year-growth rate of output, lagged interest rate.
- Our labor market structure.

Estimation

- Bayesian impulse response matching.
- VAR based on pre-2008 data:
 - Macro variables and real wage, hours worked, unemployment, job finding rate, vacancies, labor force.
- Identify shocks to monetary policy, neutral and investment-specific technology.
- Parameter estimates minimize distances between model and VAR impulse responses.
 - Responses in our model resemble responses in data.

Estimated Replacement Ratio

- Replacement ratio: unemployment payments relative to wage.
 - In model, estimated to be 0.19 (i.e., 19%).

- Direct data measure:

$$\frac{\text{gov't payments for unemp. insurance per unemployed}}{\text{compensation per employed worker}}$$

- Mean of ratio in our sample period, 14%.
- Standard DMP model requires replacement ratio $> 90\%$ to reproduce volatility of labor market data (Hagedorn-Manovskii).
- People out of labor force account for virtually all of home production.

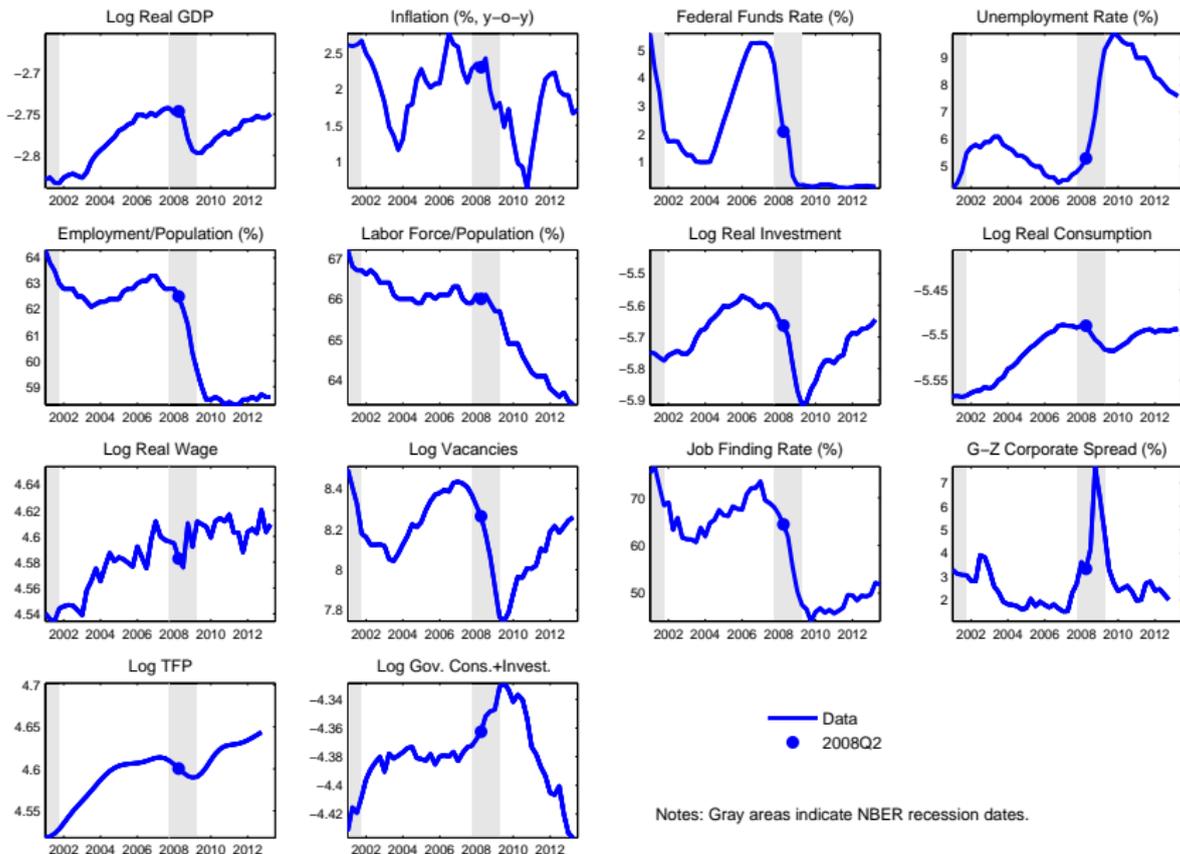
Accounting for the Great Recession

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

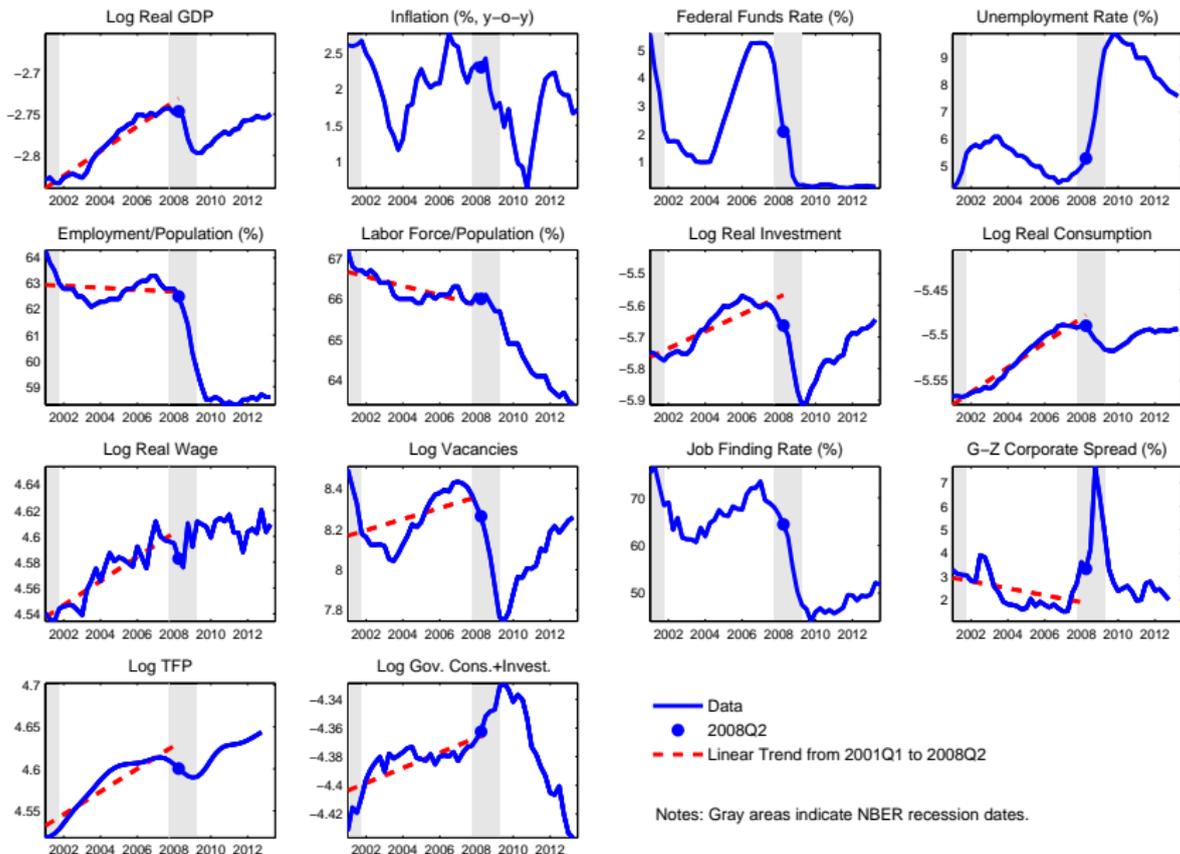
The U.S. Great Recession

- To assess how economy would have evolved absent large shocks driving Great Recession:
 - With five exceptions, we fit linear trend from 2001Q1 to 2008Q2.
 - Extrapolate trend line for each variable.
 - Our model implies all nonstationary variables are difference stationary.
 - Our linear extrapolation procedure implicitly assumes that shocks in 2001-2008 were small relative to drift terms in time series.
- Same procedure as in Hall (2014) except he starts trend in 1990, obtains similar results.

The U.S. Great Recession

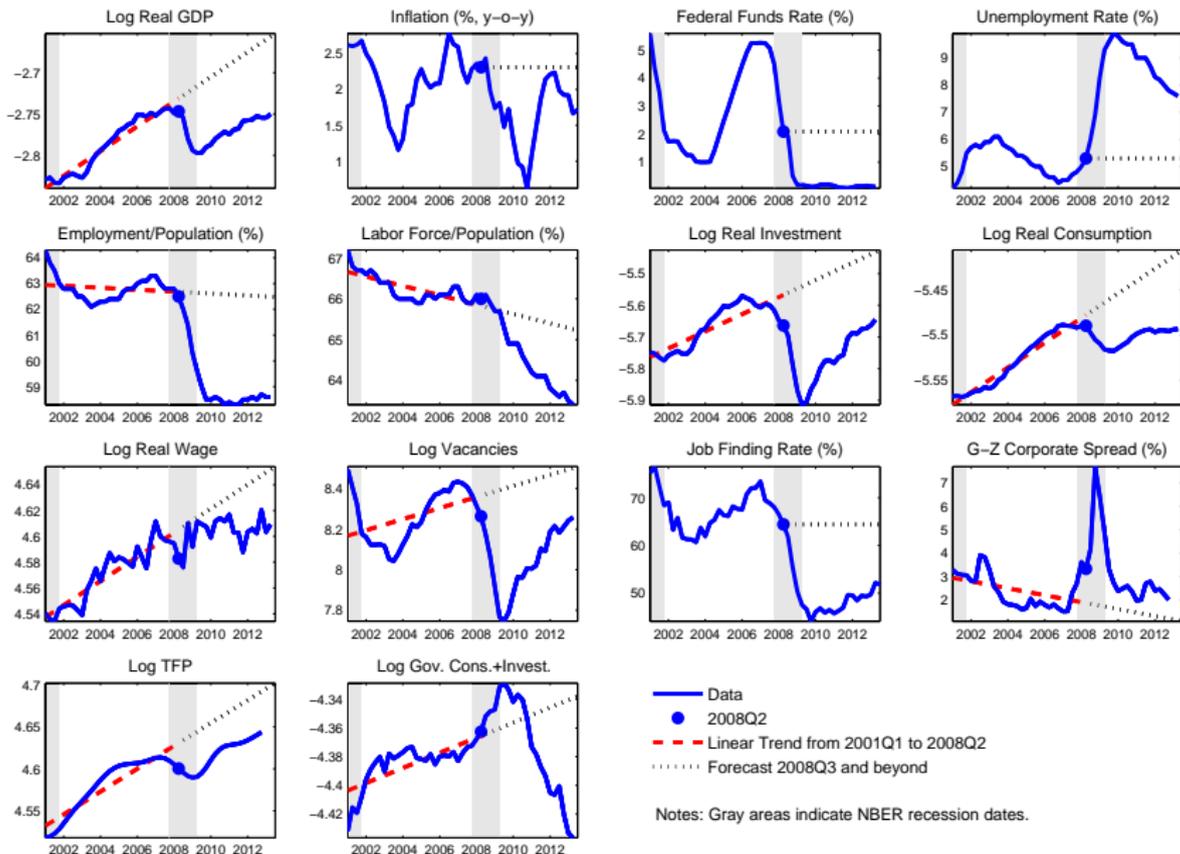


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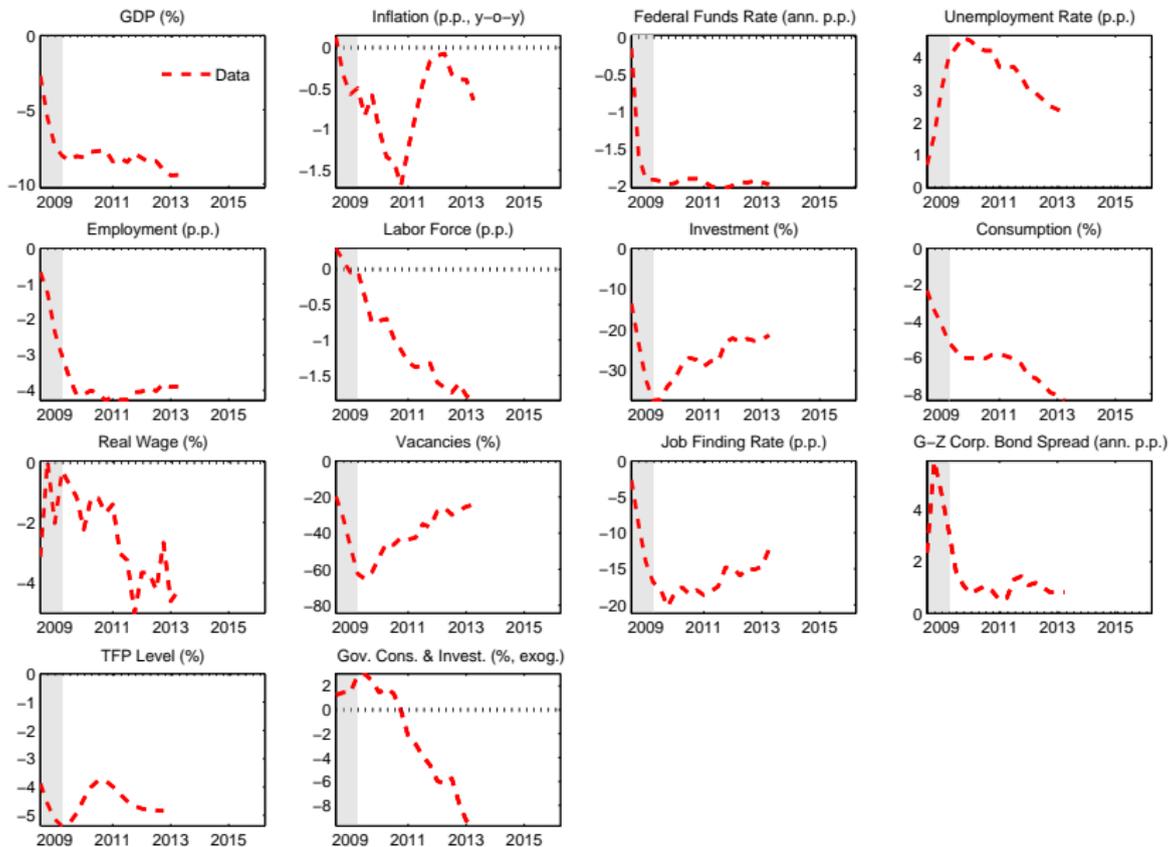


Notes: Gray areas indicate NBER recession dates.

The U.S. Great Recession



The U.S. Great Recession: Data Targets



Two Financial Market Shocks

- ① *Consumption wedge*, Δ_t^b : Shock to demand for safe assets ('Flight to safety', see e.g. Fisher 2014):

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

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- ② *Financial wedge*, Δ_t^k : Reduced form of 'risk shock', Christiano-Davis (2006), Christiano-Motto-Rostagno (2014):

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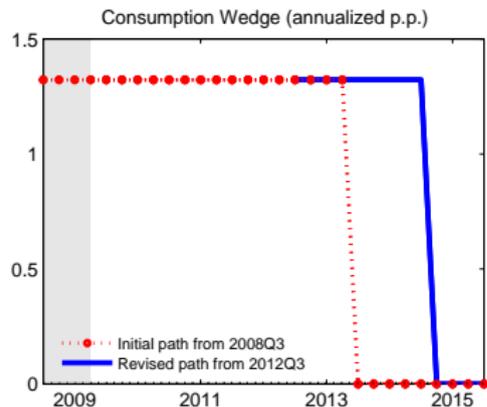
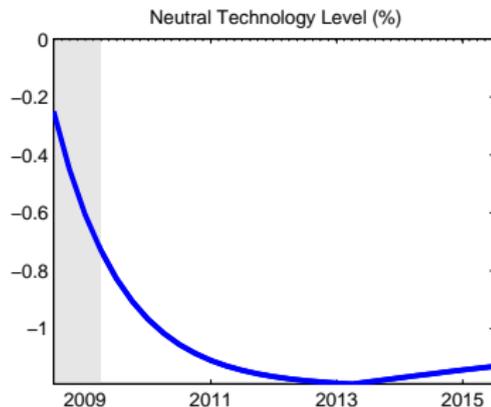
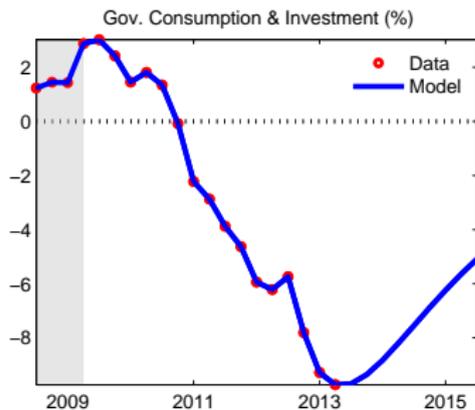
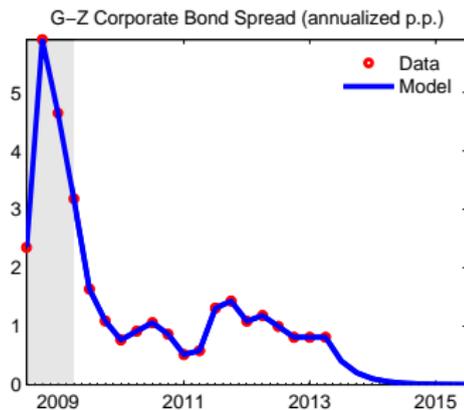
$$1 = (1 - \Delta_t^k) E_t m_{t+1} R_{t+1}^k / \pi_{t+1}$$

- Financial wedge also applies to working capital loans:
 - Interest charge on working capital: $R_t (1 + \Delta_t^k)$
 - Assume 1/2 of labor inputs financed with loans.
 - Higher financial wedge directly increases cost to firms.

Measurement of Shocks

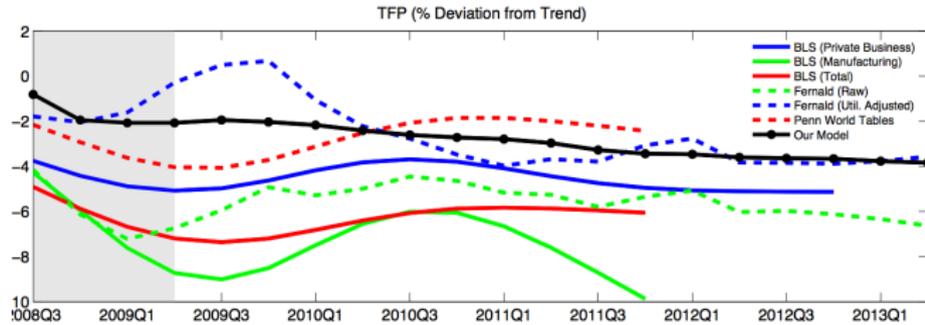
- ① Financial wedge, $1 - \Delta_t^k$, measured using GZ spread data.
 - ② Government shock measured using G data.
 - ③ Neutral technology shock based on TFP data.
 - ④ We don't have data on the consumption wedge, Δ_t^b .
 - In 2008Q3, agents expect Δ_t^b to jump from 0 to 0.33% until 2013Q2.
 - In 2012Q3 agents revise expectation and expect Δ_t^b to remain up until 2014Q3 (stand-in for fiscal cliff, sequester).
- Stochastic simulation starting 2008q3 (nonlinear model, no perfect foresight).

Exogenous Processes



Notes: Data are the differences between raw data and forecasts, see Figure 4

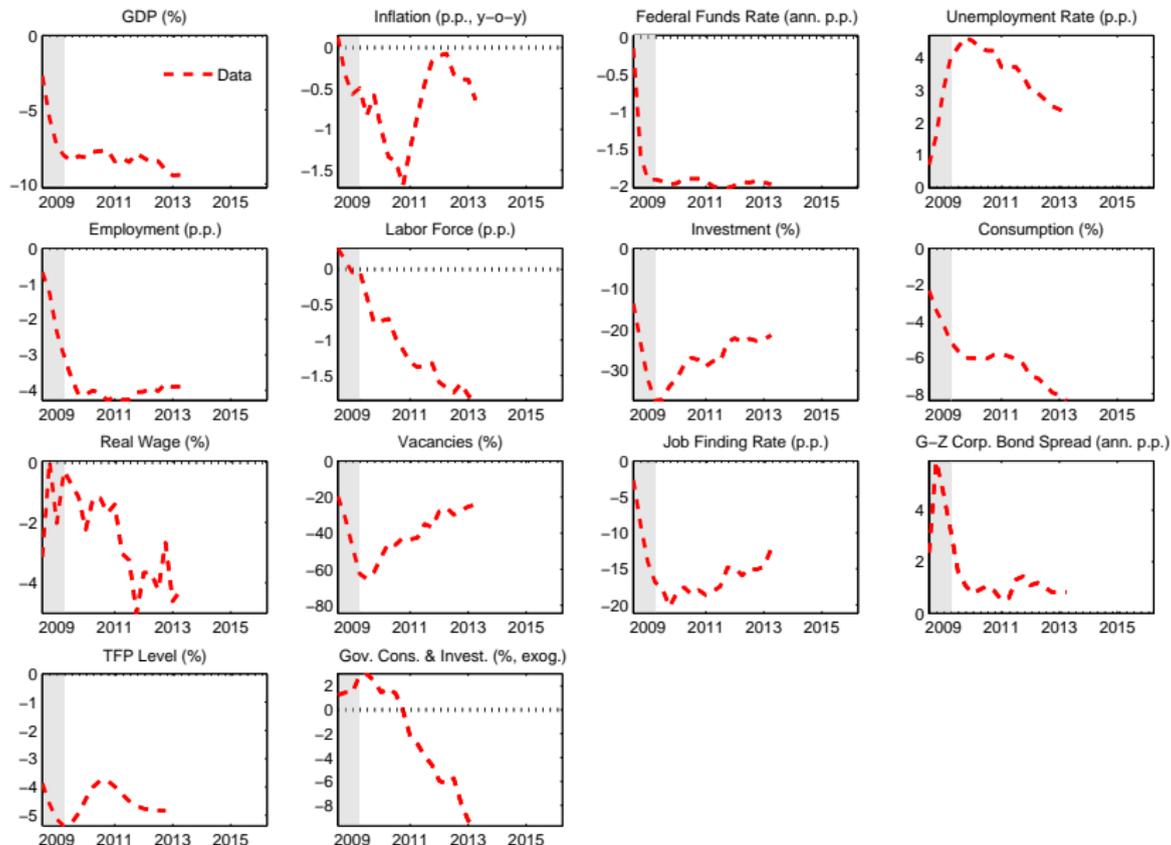
Assessing model's implication for TFP



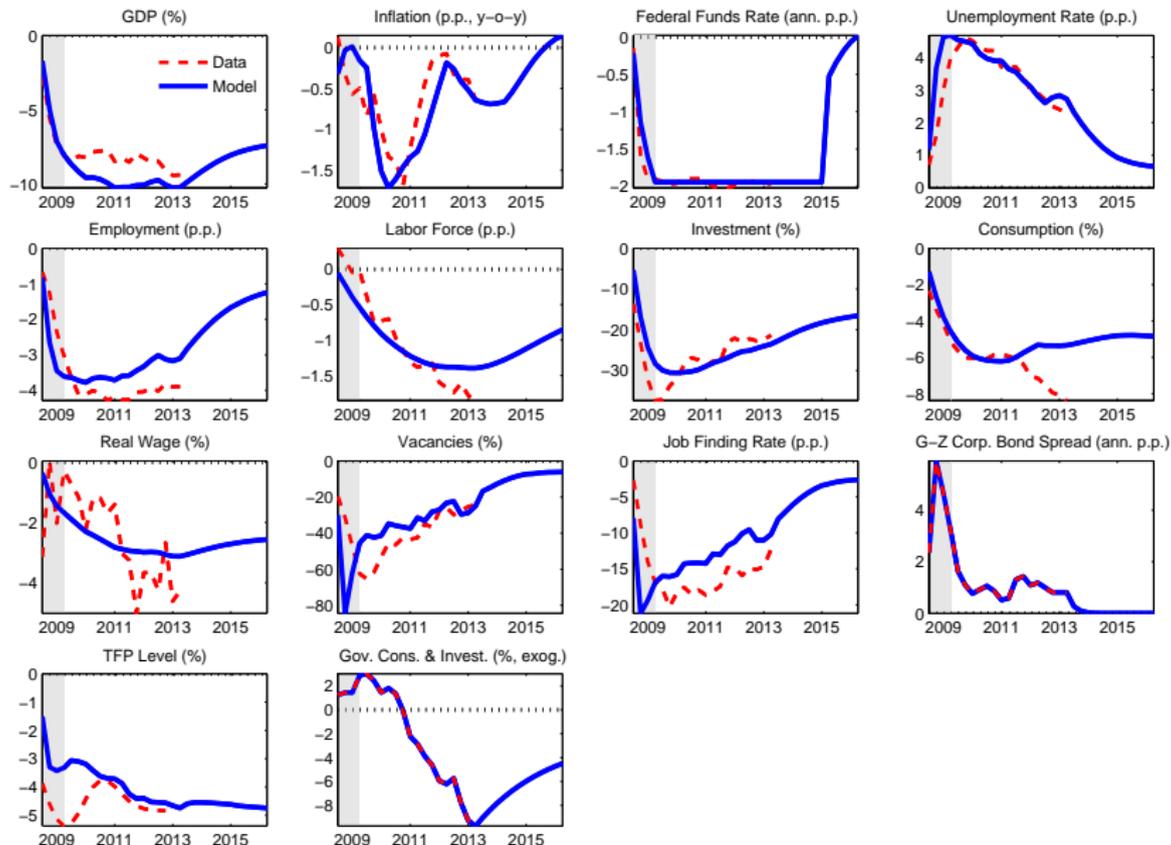
Monetary Policy in the Great Recession

- From 2008Q3 to 2011Q2:
 - Taylor-type feedback rule subject to the ZLB.
- Policy from 2011Q3-2012Q4:
 - Date-based forward guidance
 - Keep funds rate at zero for next 8 quarters.
- Policy from 2013Q1:
 - keep funds rate at zero until either unemployment falls below 6.5% or inflation rises above 2.5%.

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



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Decomposing What Happened into Shocks

- 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:
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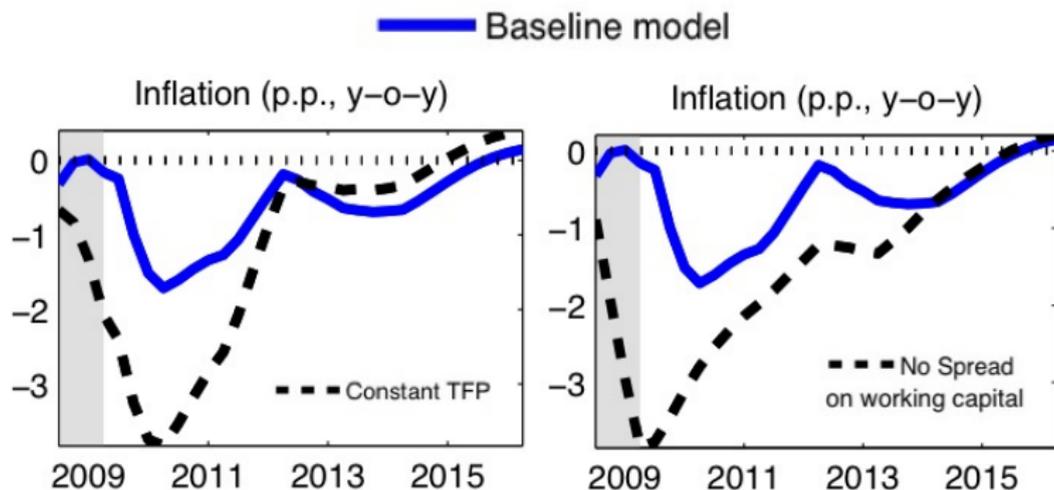
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Phillips Curve

- 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 (e.g. Christiano, Eichenbaum and Rebelo, 2011).
- Alternative: standard Phillips curve misses sharp rise in costs
 - Unusually high cost of credit to finance working capital.
 - Fall in TFP.

⇒ *Both raise countervailing pressure on inflation.*

Decomposition for Inflation

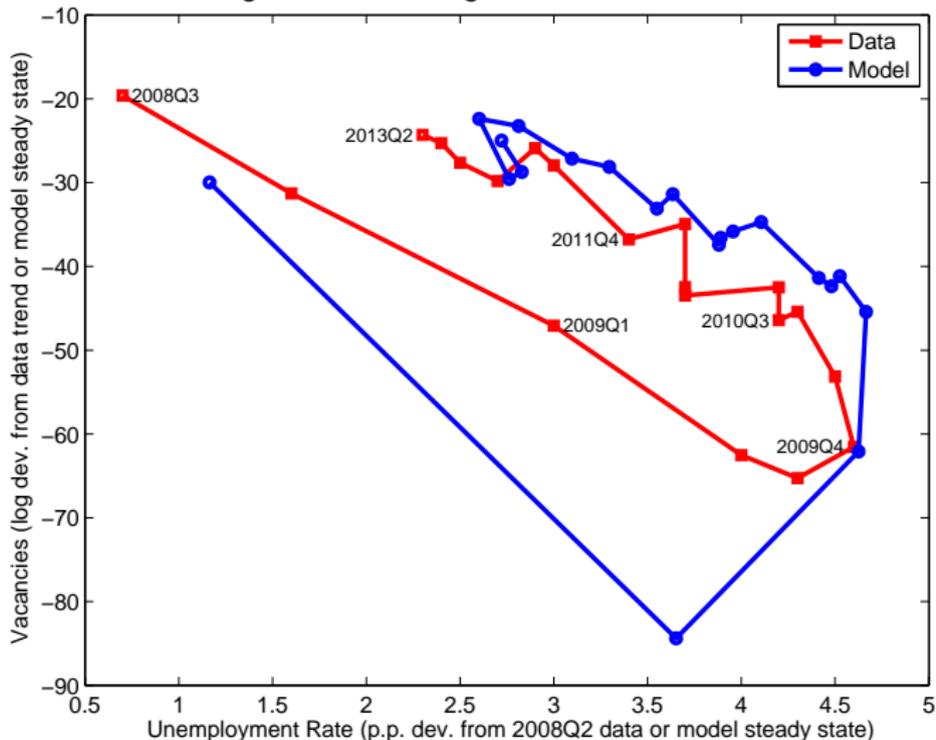


Beveridge Curve

- Much attention focused on 'sharp' rise in vacancies and relatively small fall in unemployment
 - Claim that fish hook shape is evidence of 'shift' in matching function.
 - This claim is based on assumption that unemployment is at steady state.
- In our model, no shift occurs in the matching technology.
 - if anything, our model predicts an even bigger 'shift' than occurred.

The Beveridge Curve: Data vs. Model

Figure 15: Beveridge Curve: Data vs. Model



Model Predicts Fish Hook, Why?

- Simplest DMP style model

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

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solving for f_t :

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

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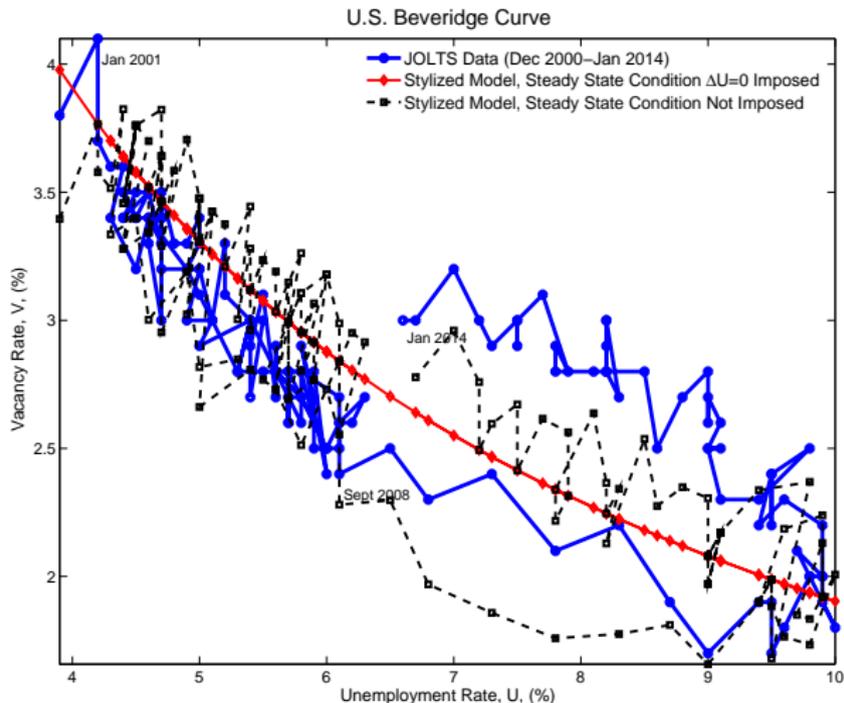
solving for V_t :

$$V_t = \left[(1 - \rho) \frac{(1 - U_t)}{\sigma_t U_t^{1-\alpha}} - \frac{U_{t+1} - U_t}{\sigma_t U_t^{1-\alpha}} \right]^{1/\alpha}$$

standard approximation sets this to zero

- Naturally implies a 'fish hook' pattern.

Magnitude of Fish Hook in DMP Model



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

Conclusion

- Bulk of movements in economic activity during the Great Recession due to 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 lens of a NK model:
 - firms face moderate degrees of price rigidities,
 - no sticky wages.
- No (or little) evidence for ‘mismatch’ in labor market.
- Modest fall in inflation is not a puzzle once fall in TFP and risky working capital channel are taken into account.

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- Vacancies have risen, but unemployment has fallen relatively little ('shift in Beveridge curve', 'mismatch').
- Investment and consumption persistently low.

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 - We stress interaction of shocks with zero lower bound (ZLB).
 - Hard to get ZLB to matter in a 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.

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 - adopt alternating offer bargaining as described in Christiano-Eichenbaum-Trabandt 2013 (build on Hall-Milgrom).

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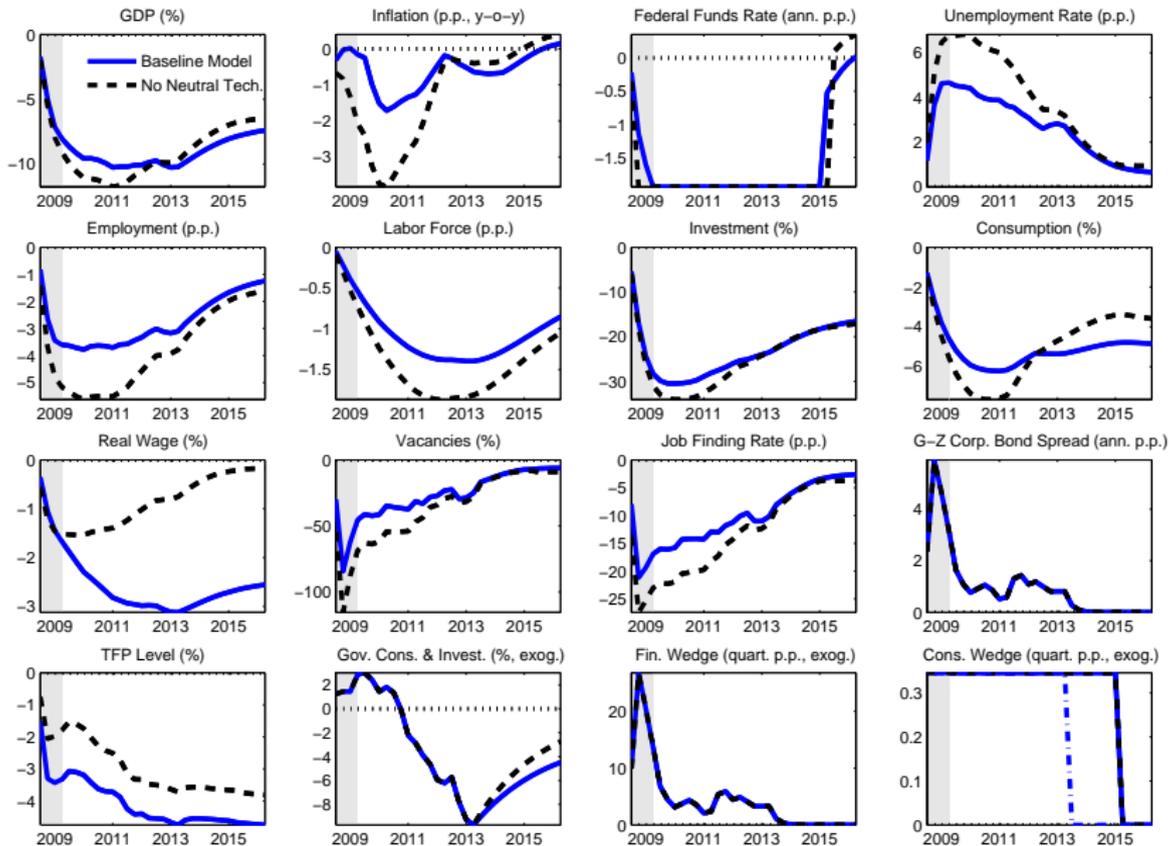
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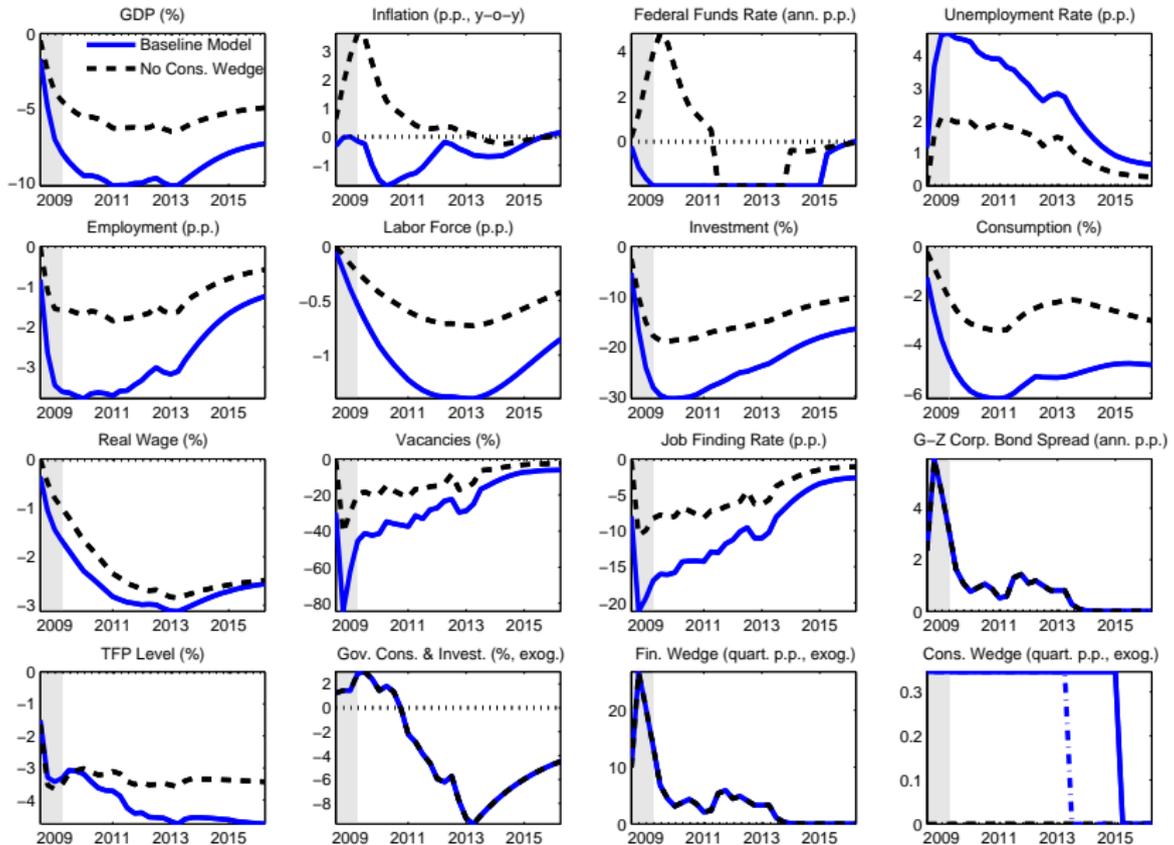
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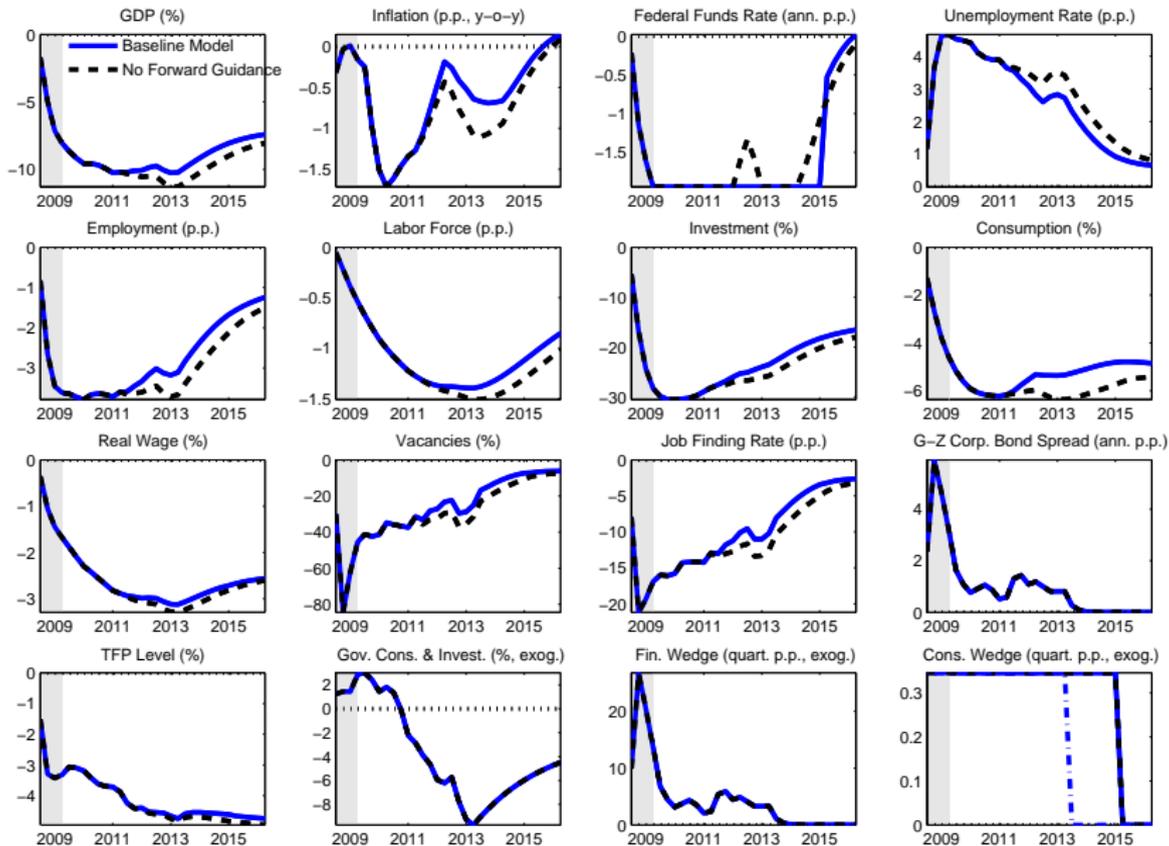
The Effect of Neutral Technology



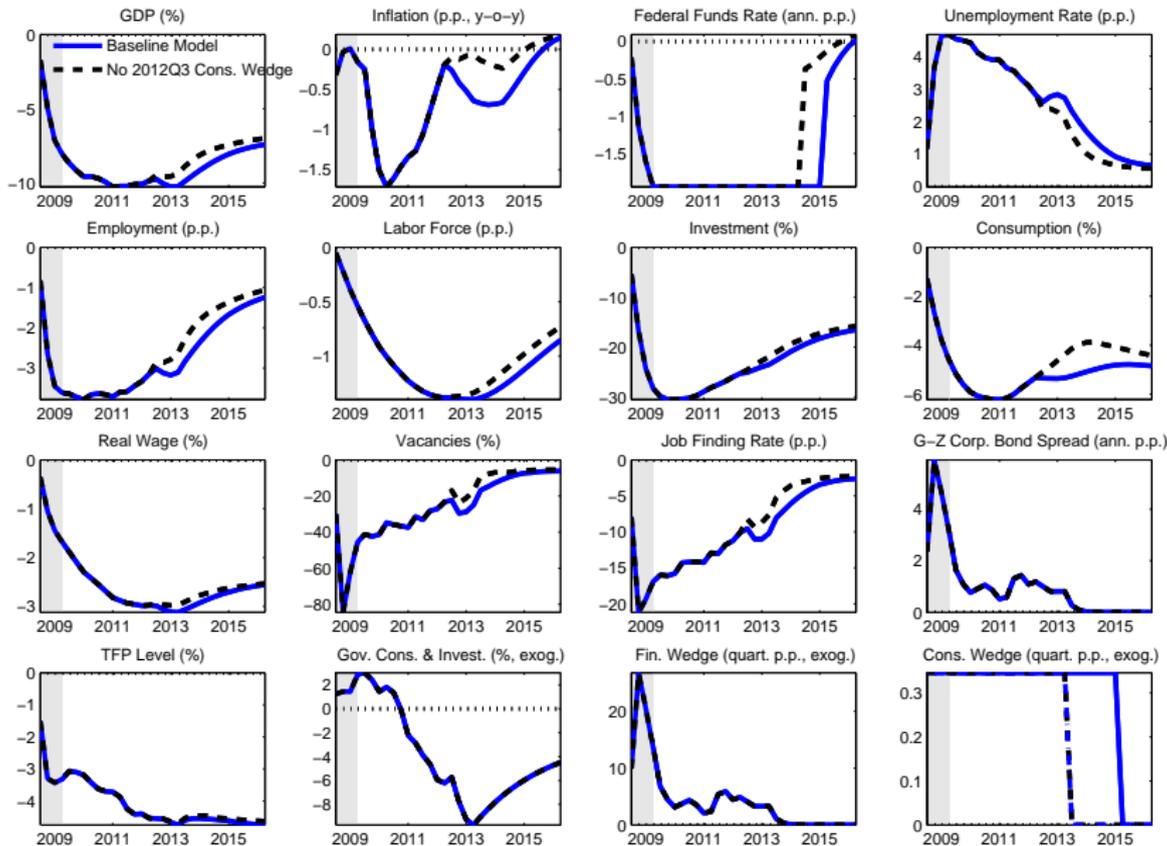
The Effect of Consumption Wedge



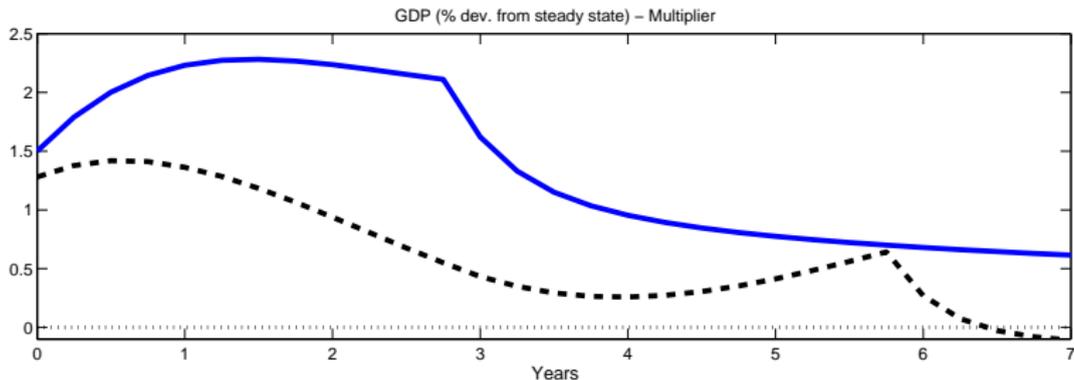
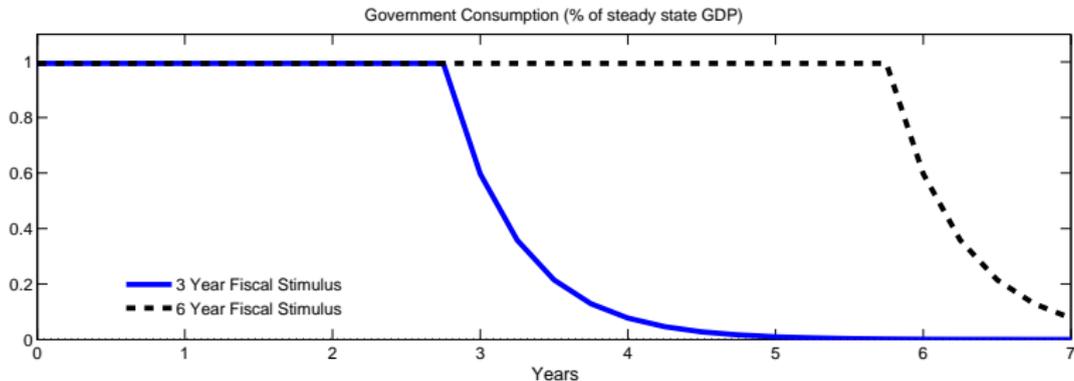
The Effect of Forward Guidance



The Effect of 2012Q3 Consumption Wedge

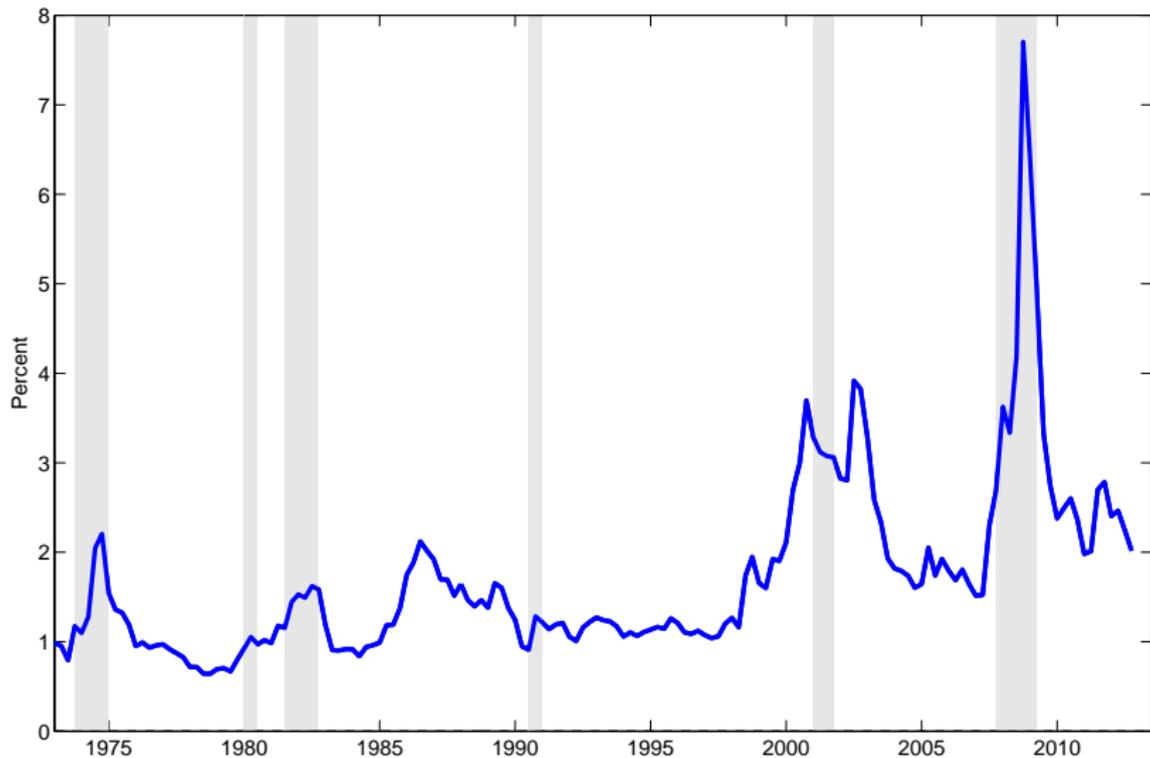


The Government Consumption Multiplier

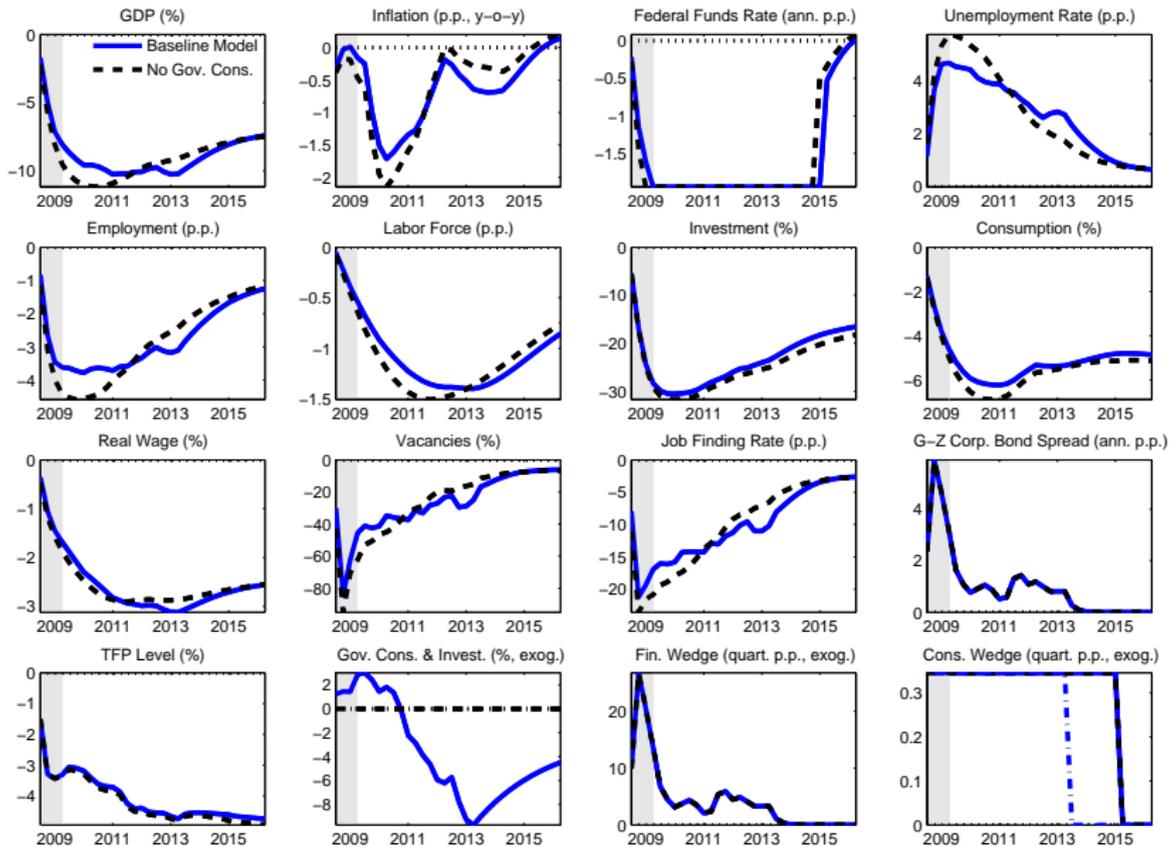


Notes: Stimulus lasts for 3 or 6 years with $AR(1)=0.6$ thereafter. 3 years constant nominal interest rate. Perfect foresight.

Gilchrist-Zakrajšek Corporate Spread



The Effect of Government Consumption



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 - G movements expected to last beyond ZLB have very small multiplier effects.
 - G beyond ZLB has negative impact on ZLB, because of depressive wealth effects on consumption.

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- Policy from 2011Q3-2012Q4: date-based forward guidance (8 quarters)
- Policy from 2013Q1:
 - keep funds rate at zero until either unemployment falls below 6.5% or inflation rises above 2.5%.

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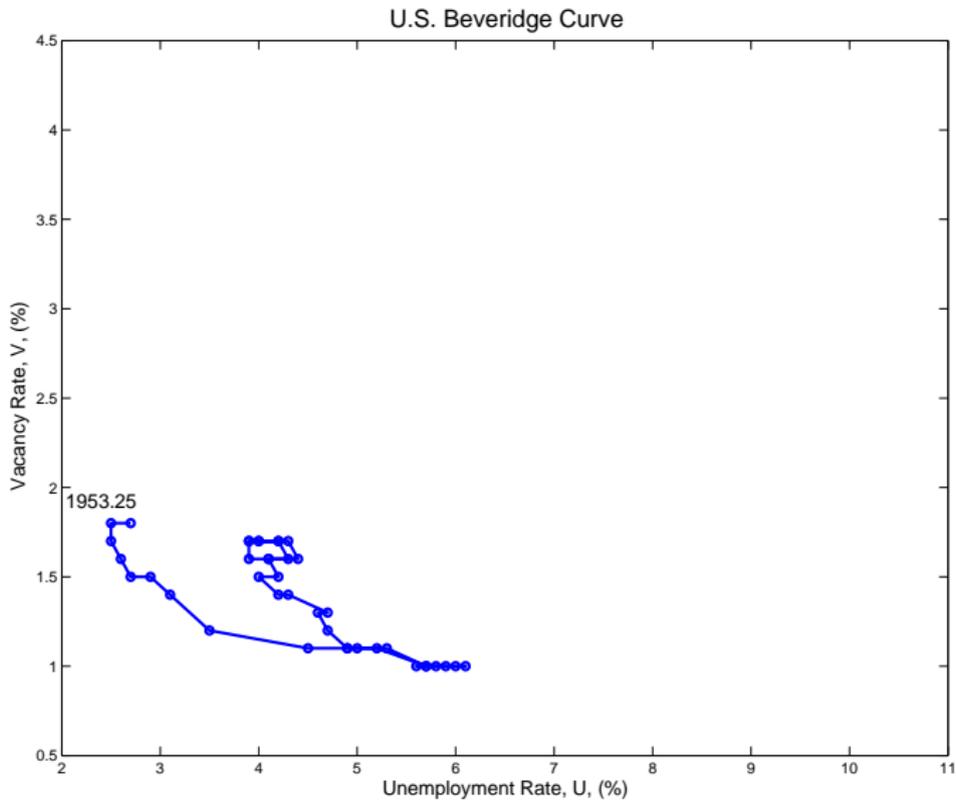
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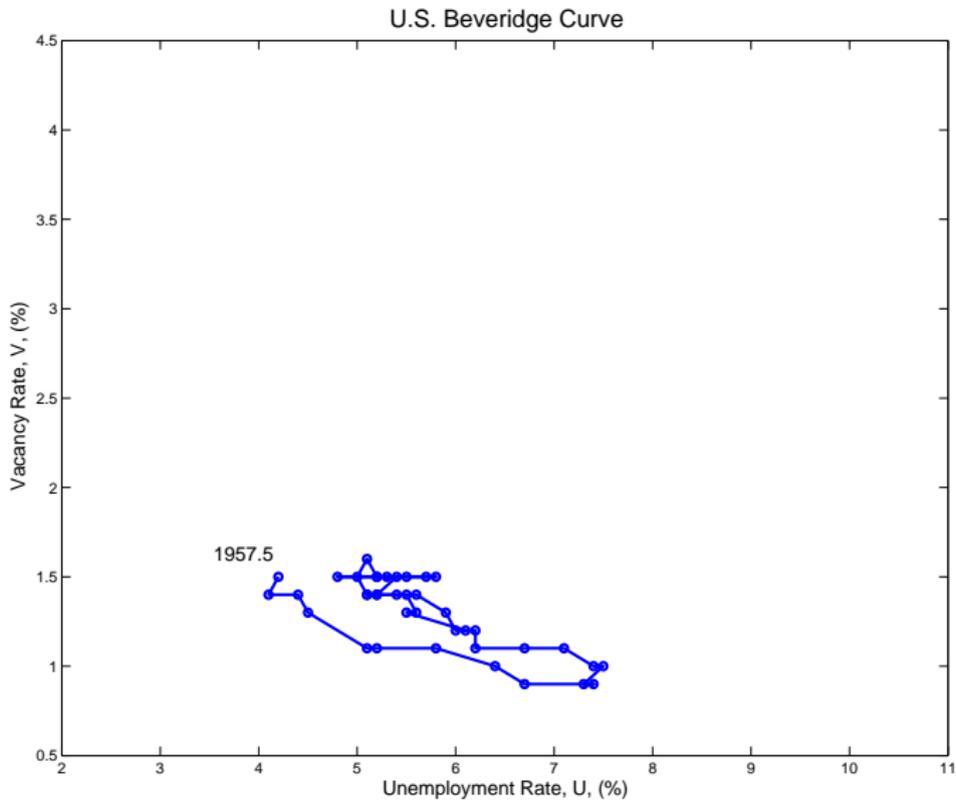
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- Solve nonlinear model, imposing certainty equivalence.

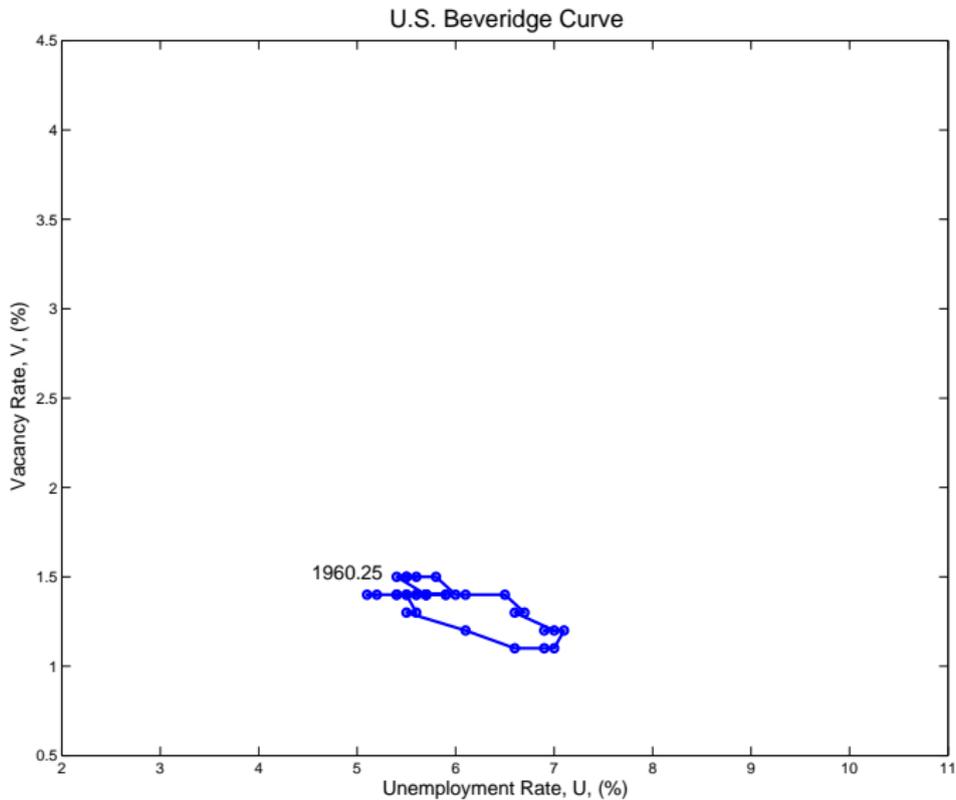
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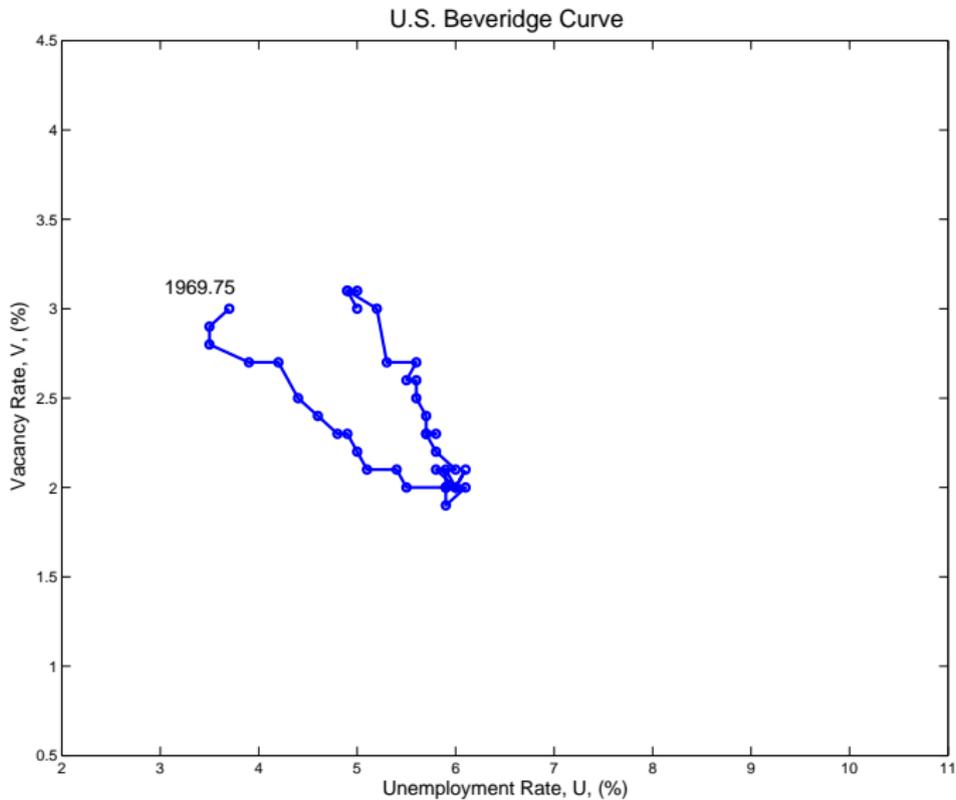
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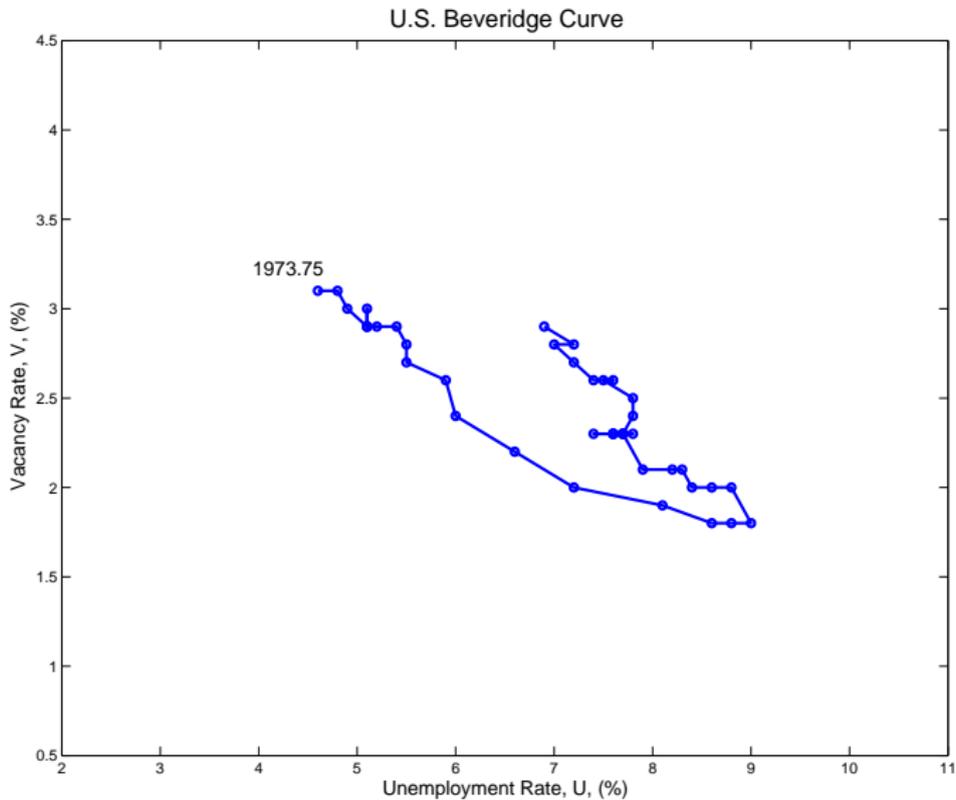
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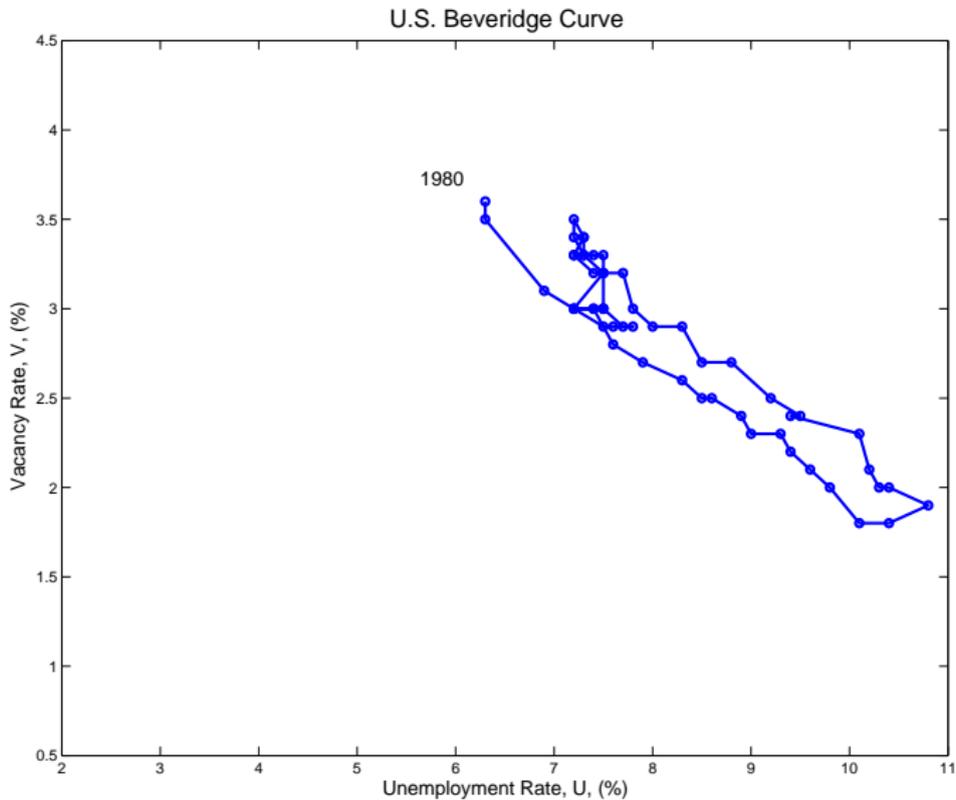
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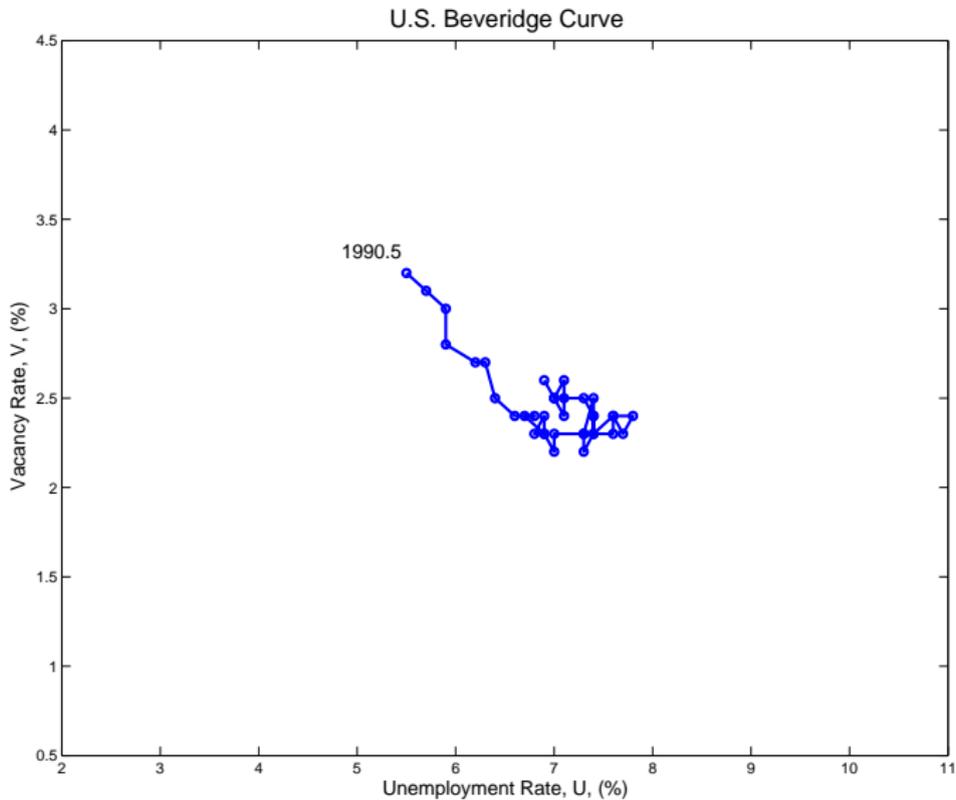
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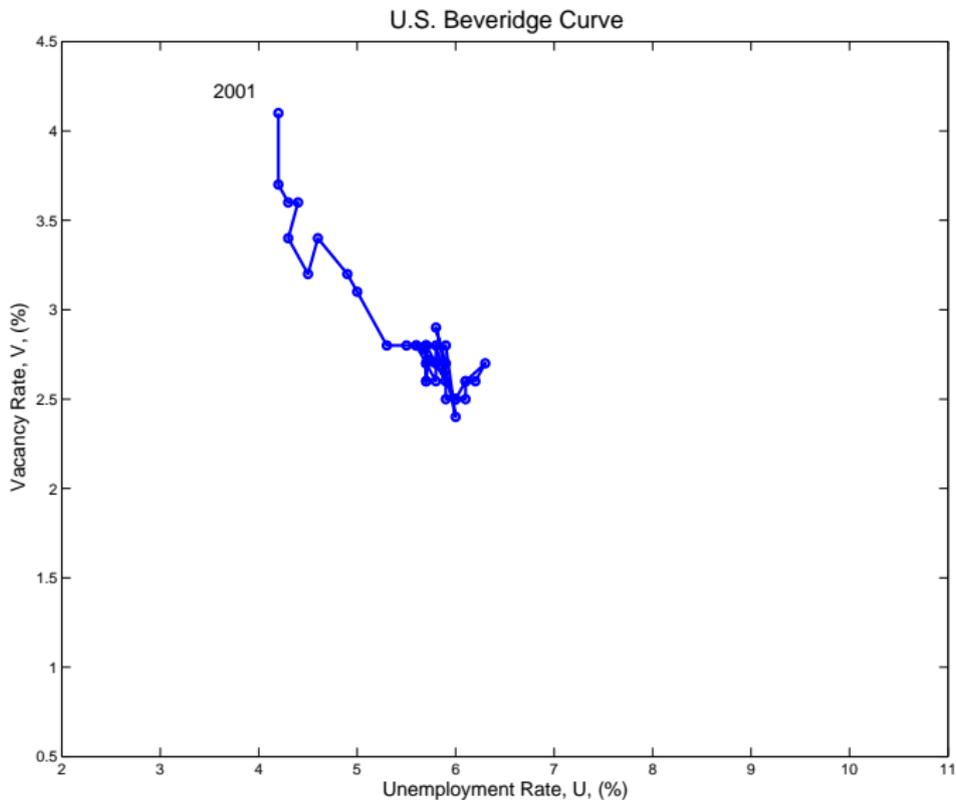
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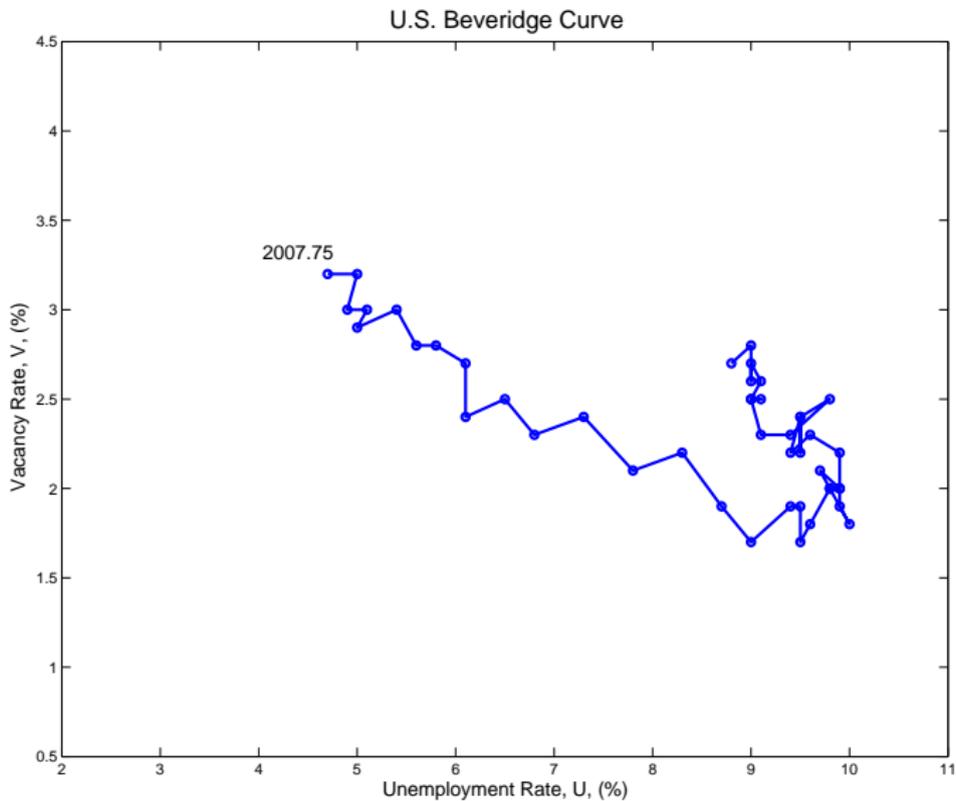
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$$\begin{array}{c} \text{separated workers at end of } t-1 \\ \underbrace{\hspace{10em}} \\ \text{employed in } t-1 \\ (1 - \rho) \quad \underbrace{l_{t-1}} \end{array} \quad + \quad \begin{array}{c} \text{unemployed in } t-1 \\ \underbrace{\hspace{10em}} \\ \text{labor force in } t-1 \\ \underbrace{L_{t-1}} \quad - l_{t-1} \end{array}$$

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- Some thrown exogenously into non-employment:

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

Beginning of Period Job Search

- Labor force at start of time t :

$$L_t = \begin{array}{l} \text{period } t-1 \text{ unemployed and separated who stay in labor force} \\ \overbrace{s(L_{t-1} - \rho l_{t-1})} \\ \text{people that were employed in previous period and remain attached} \\ + \\ \overbrace{\rho l_{t-1}} \\ \text{people sent to labor force from non-employment} \\ + \\ \overbrace{r_t} \end{array}$$

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

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

Job Finding

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

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

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

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