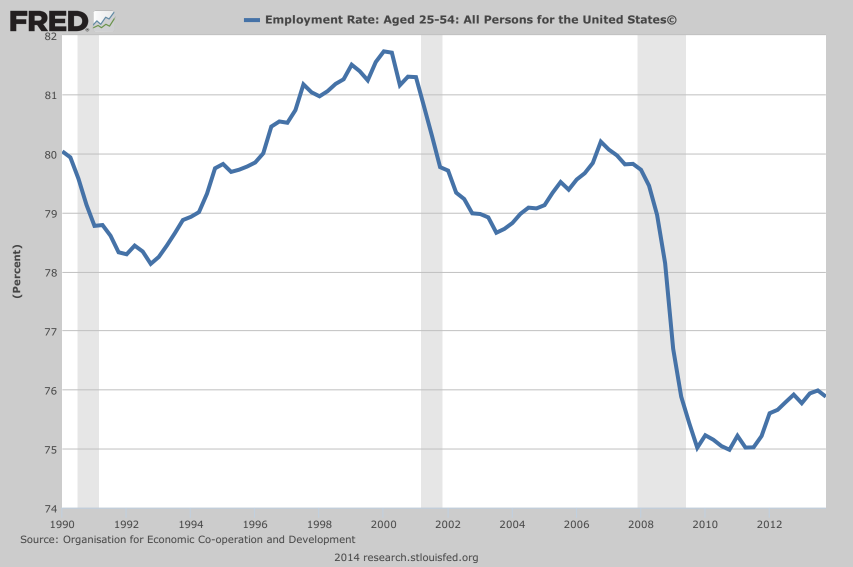
Debt Constraints and Employment

Patrick Kehoe, Virgiliu Midrigan and Elena Pastorino

Motivation: U.S. Great Recession

- Large, persistent drop in employment

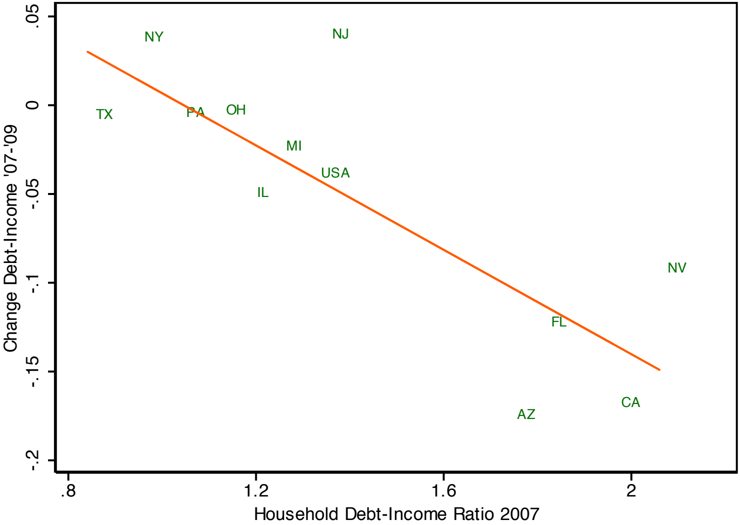
U.S. Employment-Population, aged 25-54



Motivation: U.S. Great Recession

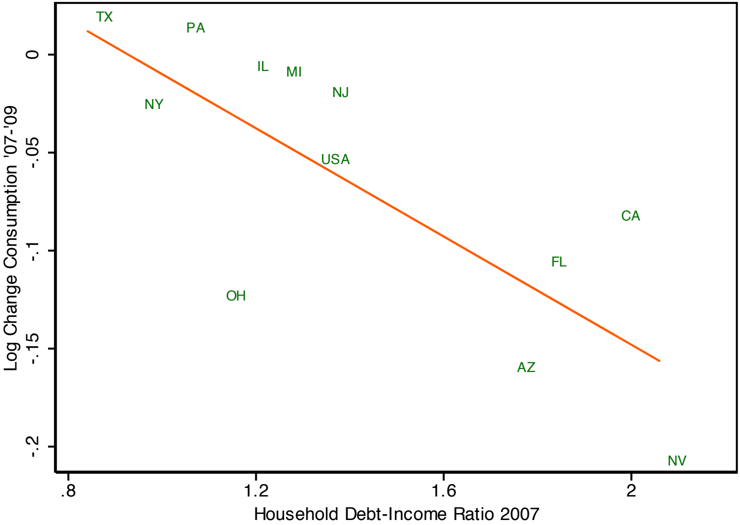
- Large, persistent drop in employment
- Regions with higher HH debt/income in 2007 experienced
  - larger decline in debt
  - larger decline in consumption
  - larger decline in employment

Δ Household Debt/Income, 2007-2009



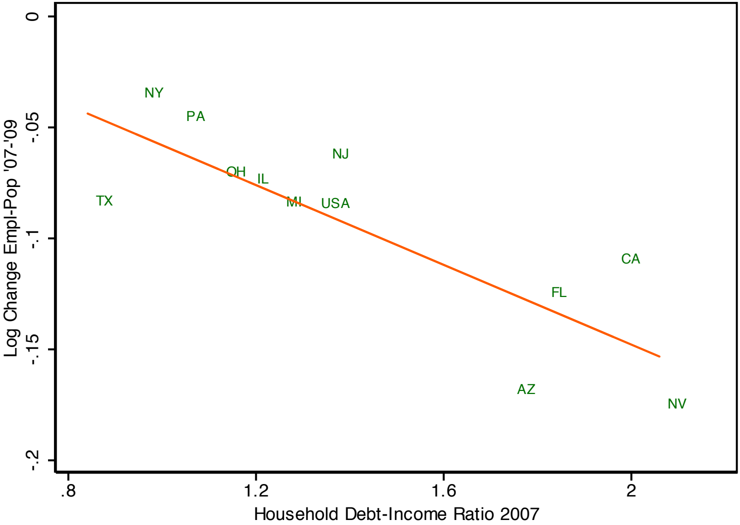
source: Midrigan and Philippon (2011)

Δ Consumption, 2007-2009



source: Midrigan and Philippon (2011)

Δ Employment/Population, 2007-2009



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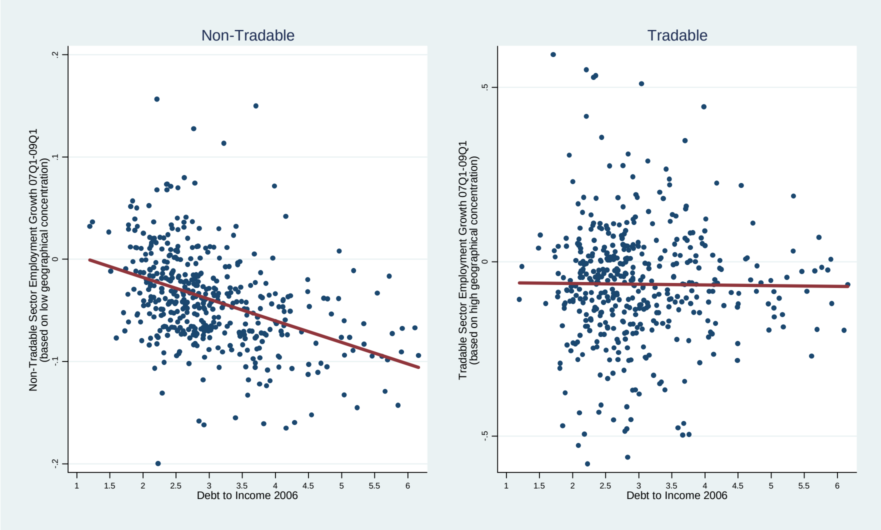
Motivation: U.S. Great Recession

- Large, persistent drop in employment
- Regions with higher HH debt/income in 2007 experienced
  - larger decline in debt
  - larger decline in consumption
  - larger decline in employment
- Regional employment drop largely due to nontradables

Employment by sector, 2007-2009



source: Mian and Sufi (2013)

U.S. Great Recession

- Popular interpretation:
  - Tightening of HH credit leads to drop in consumption
  - Drop in consumption leads to drop in employment

- At odds with predictions of standard models
  - Consumption and leisure normal goods
  - Absent relative price changes move together

- Unless prices or wages are sticky
  - Need to assume lots of stickiness
  - Guerrieri-Lorenzoni, Midrigan-Philippon

We study alternative mechanism

- Tighter debt constraints $\rightarrow$ less consumption & less employment

- Idea: large returns to tenure/experience
  - Work is an investment
  - HH debt constraints reduce returns to such investments
  - Make employment less valuable

Alternative mechanism

- Otherwise standard DMP setup
- When debt constraints are tighter
  - Consumers discount returns to experience *more*
  - Firms discount future profits *more*
  - So surplus from match is reduced

  $\Rightarrow$ Firms create fewer vacancies
- Do not explicitly impose wage rigidities
  - But arise endogenously due to debt constraints

Model overview

- Continuum of islands in small open economy. Labor immobile
- Diamond-Mortensen-Pissarides with
  - on-the-job human capital accumulation
  - idiosyncratic shocks to worker human capital
  - full insurance inside household
  - household debt limit
- No aggregate uncertainty
- Study effect of one-time, unanticipated tightening of debt limit
  1. economy-wide collateral constraint (U.S. recession)
  2. island collateral constraint (predictions for U.S. regions)

Outline

1. Response to economy-wide shock to credit constraint
   - No changes in relative prices
   - No reallocation between tradeable/non-tradeable
   - Identical to those of one good model

2. Island-specific shock to credit constraint
   - Changes in relative prices & terms of trade
   - Labor reallocation from non-tradeable to tradeable
   - More notation, leave for later

One-Good Economy

Household's problem

- Consists of measure 1 of workers and continuum firms.
- Income of worker i : y_{it} = wages or home production
- T_t: profits net of vacancy posting costs

$$\max \sum_t \beta^t u(c_t)$$

s.t.

$$c_t + a_{t+1} = (1+r) a_t + \int y_{it} di + T_t$$

Borrowing constraint:

$$a_{t+1} \geq -d_t$$

- d_t and r_t exogenous. Study effect of unanticipated changes

Household's problem

- Debt constraint binds as long as $u'(c_t)/u'(c_{t+1}) > \beta(1+r)$
  - Binds in steady state and our experiments
- Problem reduces to choosing employment & vacancies
- $Q_t = u'(c_t)$: multiplier on date t budget constraint
- Stochastic OLG structure:
  - ϕ: worker survival probability

Technology and Human Capital

- Newborns enter with human capital

$$\log(z) \sim N(0, \sigma_z^2/(1-\rho_z^2))$$

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- On-the-job human capital accumulation/off-the-job depreciation
  - employed draw z from $F_e(z'|z)$ (drifts up)

$$\log z' = (1-\rho_z)\mu_z + \rho_z \log z + \sigma_z \varepsilon'$$

  - non-employed draw z from $F_u(z'|z)$ (drifts down)

$$\log z' = \rho_z \log z + \sigma_z \varepsilon'$$

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$$\log z' = \rho_z \log z + \sigma_z \varepsilon'$$

- Employed: produce z and receive wage $w_t(z)$
- Non-employed: produce b

Matching technology

$$M\left(u_t, v_t\right) = B u_t^{\eta} v_t^{1-\eta}$$

- Market tightness: $\theta_t = v_t / u_t$

- Probability firm finds worker

$$\lambda_{f,t} = \frac{M\left(u_t, v_t\right)}{v_t} = \left(\frac{u_t}{v_t}\right)^{\eta} = B\theta_t^{-\eta}$$

- Probability worker finds firm

$$\lambda_{w,t} = \frac{M_t\left(u_t, v_t\right)}{u_t} = \left(\frac{v_t}{u_t}\right)^{1-\eta} = B\theta_t^{1-\eta}$$

Worker values

- Match exogenously destroyed with probability σ
- Discounted lifetime income if currently *employed*:

$$\begin{aligned} W_t(z) &= \omega_t(z) + \beta\phi\frac{Q_{t+1}}{Q_t}(1-\sigma)\int \max\left[W_{t+1}(z'), U_{t+1}(z')\right] dF_e(z'|z) \\ &\quad +\beta\phi\frac{Q_{t+1}}{Q_t}\sigma\int U_{t+1}(z')\, dF_e(z'|z) \end{aligned}$$

- Discounted lifetime income if currently *not employed*:

$$\begin{aligned} U_t(z) &= b + \beta\phi\frac{Q_{t+1}}{Q_t}\lambda_{w,t}\int \max\left[W_{t+1}(z'), U_{t+1}(z')\right] dF_u(z'|z) + \\ &\quad \beta\phi\frac{Q_{t+1}}{Q_t}(1-\lambda_{w,t})\int U_{t+1}(z')\, dF_u(z'|z) \end{aligned}$$

Value of filled vacancy

$$J_t(z) = z - \omega_t(z) + \beta\phi\frac{Q_{t+1}}{Q_t}\int \max\left[J_{t+1}(z'), 0\right] dF_e(z'|z)$$

Wages

- Assume wages renegotiated period by period
- Nash bargaining:

$$\max_{\omega_t(z)} \left[W_t(z) - U_t(z) \right]^{\gamma} J_t(z)^{1-\gamma}$$

$$\frac{\gamma}{W_t(z) - U_t(z)} = \frac{1-\gamma}{J_t(z)}$$

Free entry condition

- Firms pay κ units of output to post vacancy

- Let $n_t^u(z)$ measure of unemployed, $\tilde{n}_t^u(z) = \frac{n_t^u(z)}{\int dn_t^u(z)}$

$$0 = -\kappa + \beta\phi\frac{Q_{t+1}}{Q_t}\lambda_{f,t}\int \max\left[J_{t+1}\left(z'\right), 0\right] dF_u\left(z'|z\right) d\tilde{n}_t^u\left(z\right)$$

- pins down θ_t

Parameterization

- Assigned parameters
  - period = 1 quarter
  - $\beta = 0.94^{1/4}$, $1 + r = 0.96^{-1/4}$, $\phi = 1 - 1/160$
  - Probability of separation: $\sigma = 0.10$ (Shimer 2005)
  - Bargaining share and elasticity matching fn: $\eta = \gamma = 1/2$
  - $u(c_t) = \frac{c_t^{1-\alpha}}{1-\alpha}$, $\quad \alpha = 5$ so IES $= 0.2$
    - Micro-evidence: IES $\approx 0.1 - 0.2$
    - Hall '88, Attanasio et. al. '02, Vissing-Jorgensen '02

- **Calibrated parameters**
  - Vacancy posting cost, κ
  - Efficiency matching function: B
  - Persistence shocks to z: ρ_z
  - Std. dev. of shocks to z: σ_z
  - Home production, b
  - Returns to work: μ_z

- **Calibrated parameters**
  - Vacancy posting cost, κ
    - Normalize steady-state market tightness $\theta = 1$
  - Efficiency matching function: B
  - Persistence shocks to z: ρ_z
  - Std. dev. of shocks to z: σ_z
  - Home production, b
  - Returns to work: μ_z

- **Calibrated parameters**
  - Vacancy posting cost, κ
  - Efficiency matching function: B
    - Employment-populatio ratio $= 0.8$ (U.S. all adults 25-54)
  - Persistence shocks to z: ρ_z
  - Std. dev. of shocks to z: σ_z
  - Home production, b
  - Returns to work: μ_z

- **Calibrated parameters**
  - Vacancy posting cost, κ
  - Efficiency matching function: B
  - Persistence shocks to z: ρ_z
    - std. dev. of log initial wages = 0.94 (PSID)
  - Std. dev. of shocks to z: σ_z
  - Home production, b
  - Returns to work: μ_z

- **Calibrated parameters**
  - Vacancy posting cost, κ
  - Efficiency matching function: B
  - Persistence shocks to z: ρ_z
  - Std. dev. of shocks to z: σ_z
    - std. dev. changes log wages $= 0.21$ (Floden-Linde 2001)
  - Home production, b
  - Returns to work: μ_z

- **Calibrated parameters**
  - Vacancy posting cost, κ
  - Efficiency matching function: B
  - Persistence shocks to z: ρ_z
  - Std. dev. of shocks to z: σ_z
  - Home production, b
    - $b/$ median $\omega = 0.4$ (Shimer 2005)
  - Returns to work: μ_z

- **Calibrated parameters**
  - Vacancy posting cost, κ
  - Efficiency matching function: B
  - Persistence shocks to z: ρ_z
  - Std. dev. of shocks to z: σ_z
  - Home production, b
  - Returns to work: μ_z
    - returns to tenure & experience data

Returns to work in the data

- Buchinsky et. al. (2010) estimate

$$\log(w_{it}) = c_i + x'_{it}\beta + f(\text{experience}_{it}) + g(\text{tenure}_{it}) + J_{it} + \varepsilon_{it}$$

- J_{it} summarizes history previous jobs $l = 1 : M_{it}$

$$J_{i,t} = \sum_{l=1}^{M_{it}} \sum_{k=1}^{4} \left(\phi_k^0 + \phi_k^s \text{tenure}_i^l + \phi_k^e \text{experience}_i^l\right) d_{k,i}^l$$

Returns to work in the data

$$\log(w_{it}) = c_i + x'_{it}\beta + f(\text{experience}_{it}) + g(\text{tenure}_{it}) + J_{it} + \varepsilon_{it}$$

Cumul. returns to experience:	5 yrs	10 yrs	15 yrs
College graduates	0.43	0.66	0.76
High School graduates	0.28	0.40	0.44
High School dropouts	0.24	0.36	0.41

Cumul. returns to tenure:	5 yrs	10 yrs	15 yrs
College graduates	0.29	0.48	0.62
High School graduates	0.28	0.48	0.62
High School dropouts	0.30	0.51	0.68

Returns to work in the data

$$\log(w_{it}) = c_i + x'_{it}\beta + f(\text{experience}_{it}) + g(\text{tenure}_{it}) + J_{it} + \varepsilon_{it}$$

- Our approach:
  - Simulate paths for experience and tenure for our model
  - Use BFKT estimates (high school grads) to evaluate

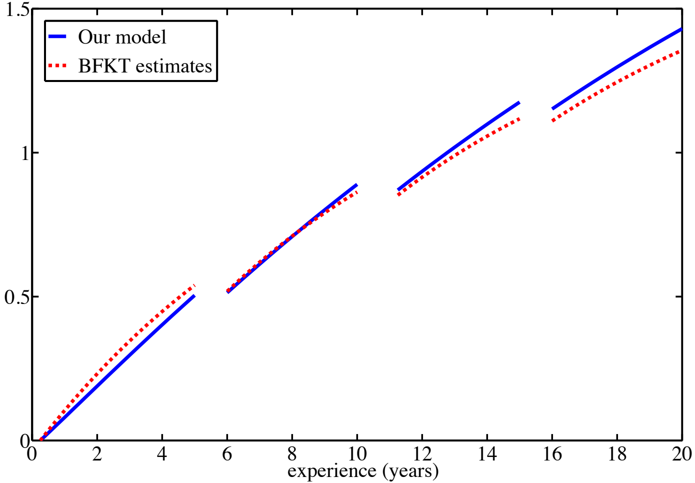
    $$\log\left(\hat{w}_{it}\right) = f(\text{experience}_{it}) + g(\text{tenure}_{it}) + J_{it}$$

  - Minimize distance mean $\Delta \log(\hat{w}_{it})$ & $\Delta \log(w_{it})$ model
    - 5.2% per year

Moments used in calibration

	Data	Model
fraction employed	0.80	0.80
mean growth rate wages	0.052	0.052
home production/ median wage	0.40	0.40
std. dev. wage changes	0.21	0.21
std. dev. initial wages	0.94	0.94

Returns to work: model vs. data



Initialize w/ 0 experience, mean z_{it} | exp = 0, no shocks

Parameter values

B	0.595	steady state match probability
ρ_z	$0.952^{1/4}$	persistence human capital
σ_z	0.112	std. dev. efficiency shocks
μ_z	2.82	returns to work
b	1.75	home production / mean z new entrant

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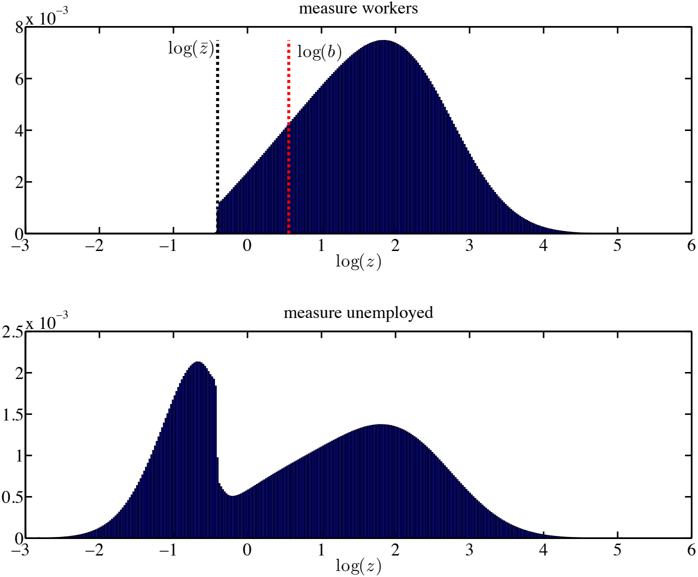
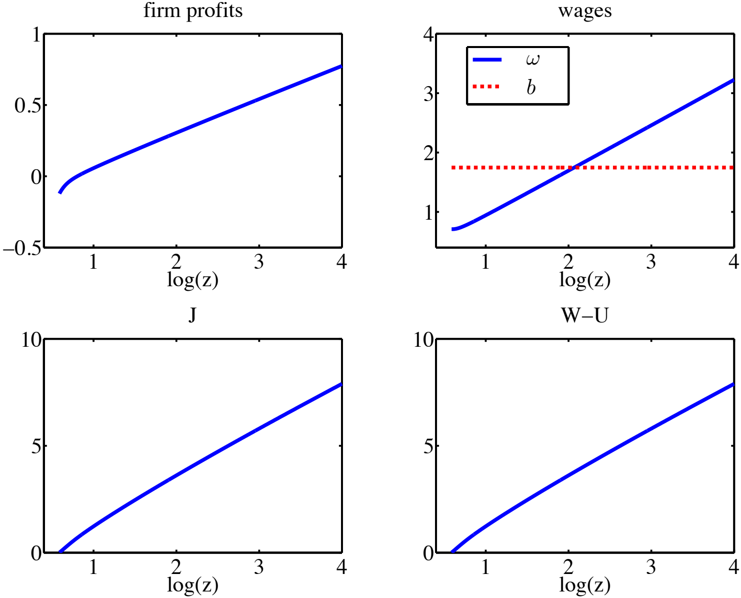
Note: b low relative to mean z of new hire: 0.24

Steady state measures



Policy and value functions



Model implications

fraction workers with $w < b$	0.181
prob. job destroyed endogenously	0.002
prob. worker matches, λ_w	0.595
fraction matches with positive surplus	0.724
drop in w after non-employment spell	1.9%
drop in w if not employed 1 year	6.1%
drop in w if not employed 2 years	8.8%

Experiment: economy-wide credit crunch

- Binding debt limit:

$$c_t = d_t - (1+r)d_{t-1} + y_t$$

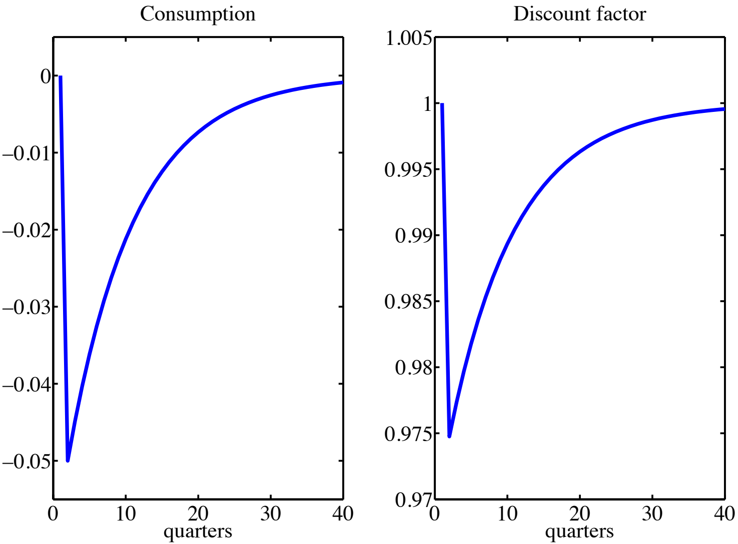
- Assume unanticipated tightening debt limit d_t

- Choose path for d_t so c_t falls 5% then mean-reverts

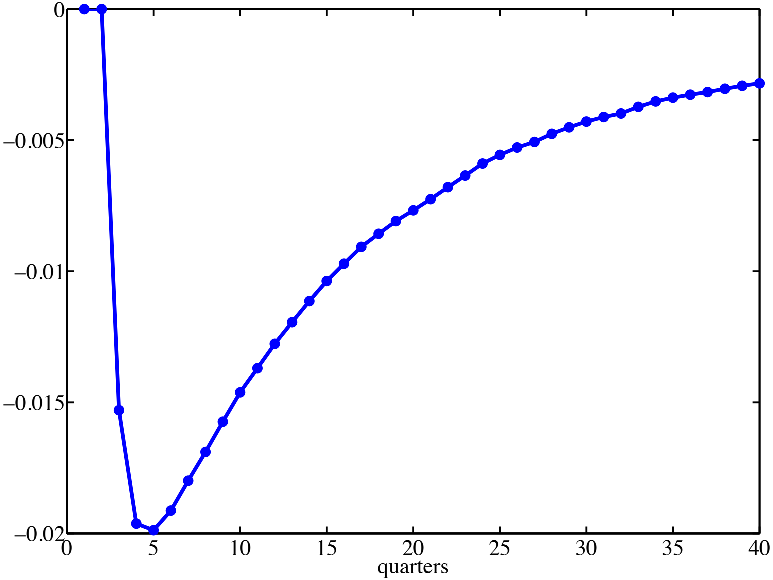
$$c_t = 0.90c_{t-1} + 0.10\bar{c}$$

- Implies future discounted more: $Q_{t+1}/Q_t = \left(\frac{c_{t+1}}{c_t}\right)^{-\alpha} \downarrow$

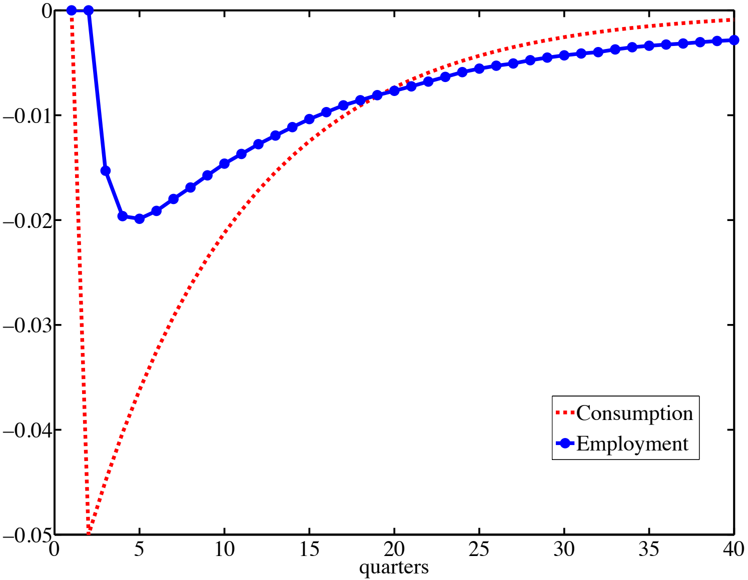
Credit crunch



Employment



Employment vs. Consumption



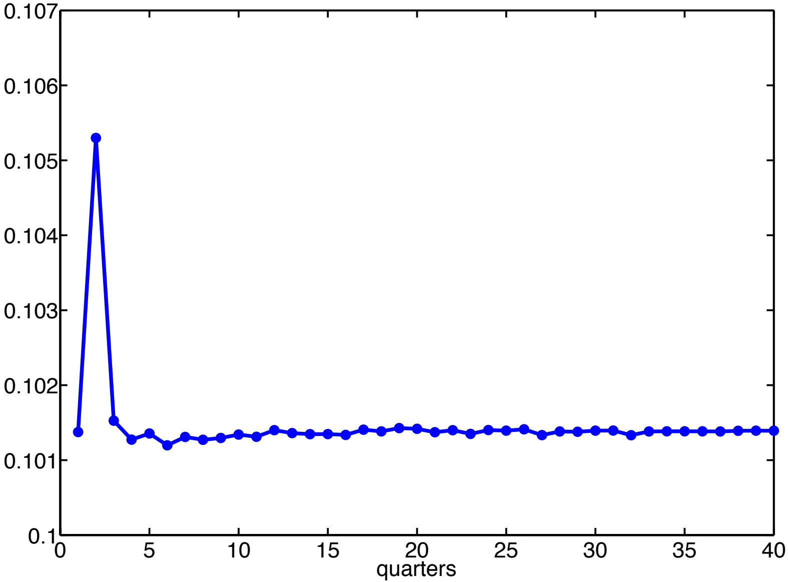
Employment response

- Maximal drop employment 2.0% vs. 5.0% drop in C
- Employment drop much more persistent
  - Cumulative impulse responses:
    - 2 years: $\mathrm{CIR}^{\mathrm{E}} = 0.44 \times \mathrm{CIR}^{\mathrm{C}}$
    - 10 years: $\mathrm{CIR}^{\mathrm{E}} = 0.69 \times \mathrm{CIR}^{\mathrm{C}}$
    - overall: $\mathrm{CIR}^{\mathrm{E}} = 0.92 \times \mathrm{CIR}^{\mathrm{C}}$

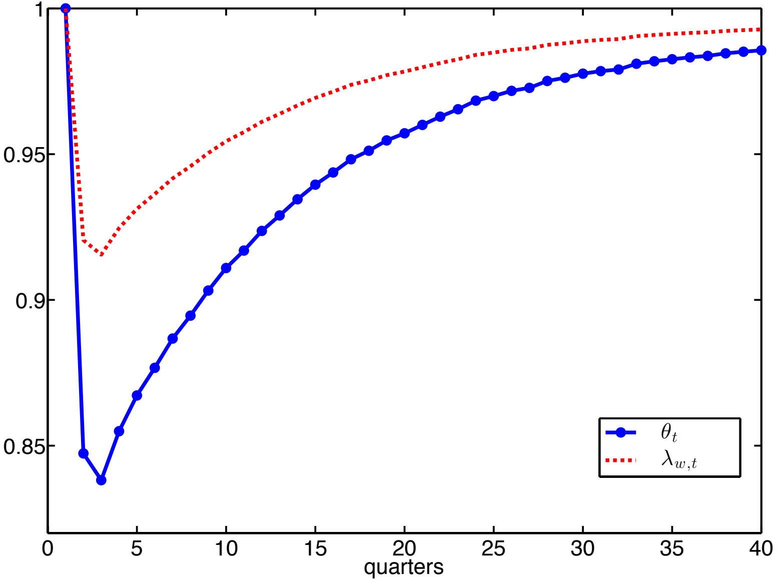
Why does employment drop?

- Drop in Q_{t+1}/Q_t reduces surplus $W_t(z) - U_t(z) + J_t(z)$
  - Reduces returns to learning by doing for workers
  - Reduces returns to posting vacancies for firms
- Employment drops because
  - Some existing matches endogenously destroyed
  - Fewer vacancies posted
  - Fewer matches have positive surplus

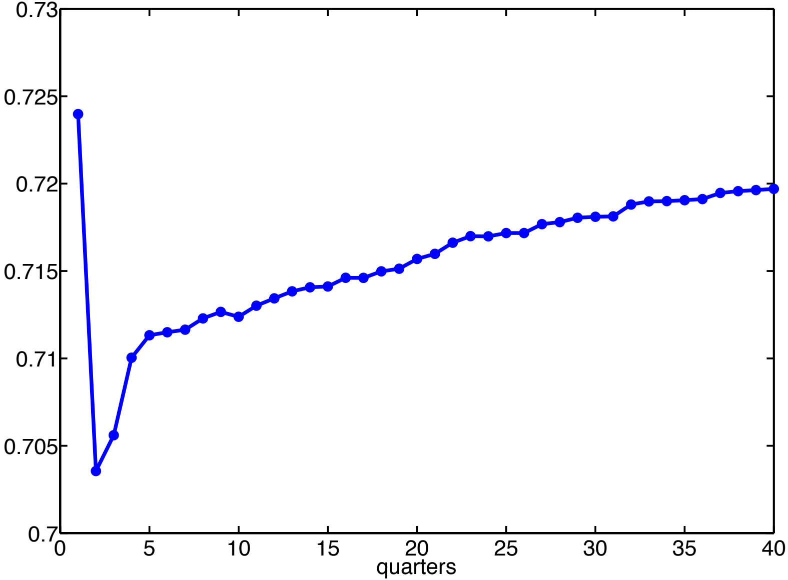
Job separations



Market tightness



Probability match accepted



Employment decomposition

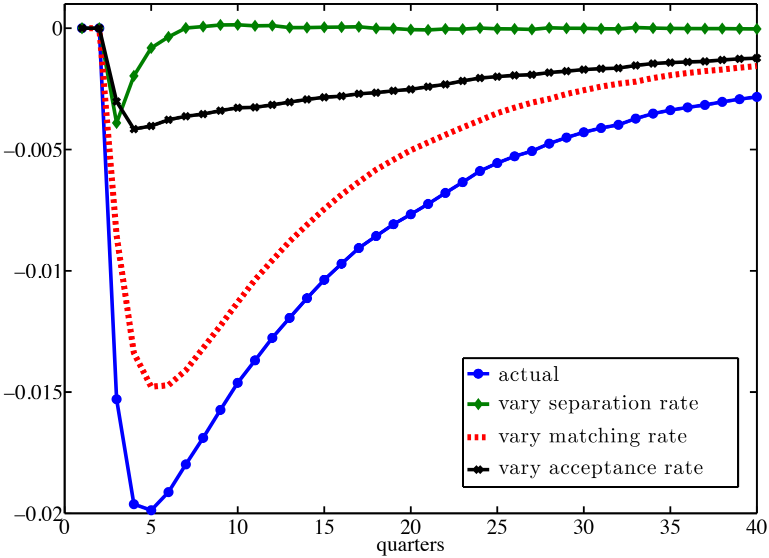
- Shimer 2012 approach

$$E_{t+1} = (1 - s_t)E_t + \lambda_{w,t} a_t (1 - E_t)$$

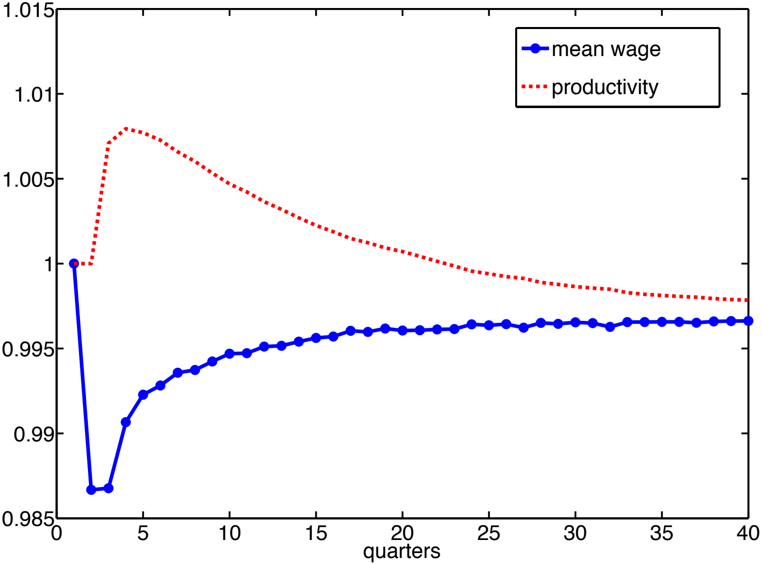
  - s_t: separation rate
  - $\lambda_{w,t}$: worker matching probability
  - a_t: acceptance rate

- Construct three counterfactual employment series:
  - Vary s_t, $\lambda_{w,t}$, a_t in isolation
  - Leave others at steady state values

Employment decomposition



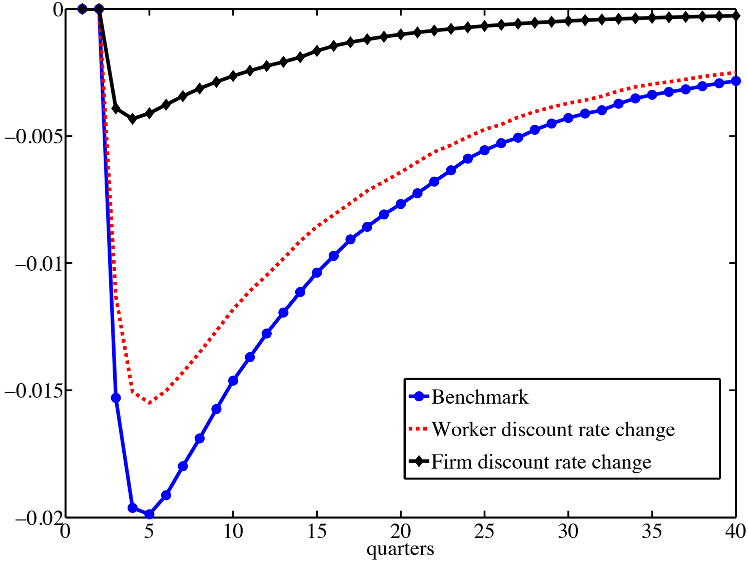
Wages and Productivity



Consumer vs. firm debt constraints

- Our benchmark model:
  - firms owned by households
  - debt constraints change discount rate of workers & firms
- Separate role of each
  - only let discount rate of workers change
  - only let discount rate of firms change

Worker vs. firm debt constraints



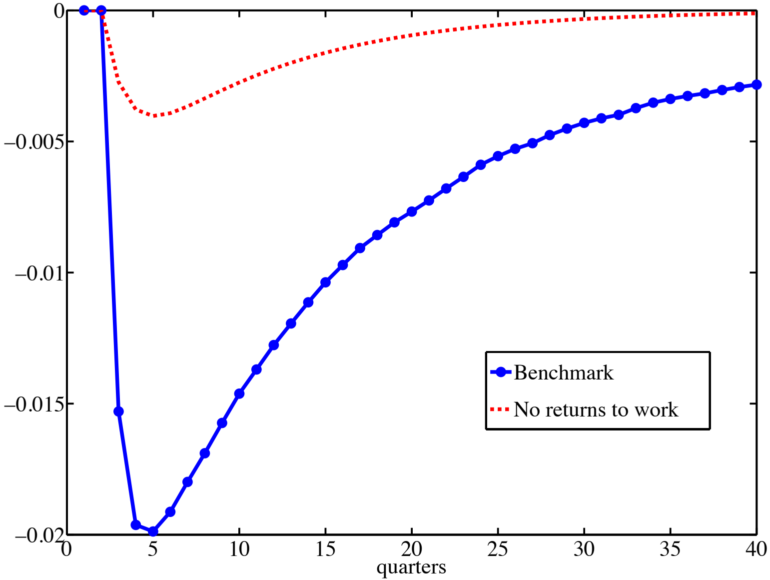
Consumer vs. firm debt constraints

- Employment drops mostly because of worker discounting
- Worker retains most human capital after separation
  - Longer horizon, surplus more sensitive to discount rate

Role of returns to work

- Employment falls much less absent returns to work
- Illustrate by setting $\mu_z = 0$ & $\sigma_z = 0$
  - Similar results with heterogeneity: $\sigma_z > 0$

No returns to work



Comparison with Hall 2014

- Results consistent with Hall 2014
- Studies effect of increase discount rate in DMP model
- Steady state effects of change in discount rate small:
    - r from 10% to 20%: U up from 5.8% to 5.88%
- Wage rigidities amplify effects

Intuition from simple model

- First, suppose no learning by doing

$$
\begin{aligned}
\rho W(z) &= \omega(z) - \sigma\left(W(z) - U(z)\right) \\
\rho U(z) &= b + \lambda_w \left(W(z) - U(z)\right) \\
\rho J(z) &= z - w(z) - \sigma J(z)
\end{aligned}
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$$

- Surplus: $S(z) = W(z) - U(z) + J(z)$

$$S(z) = \frac{z-b}{\tilde{\rho}}$$

  - $\tilde{\rho} = \rho + \sigma + \frac{1}{2}\lambda_w$
  - not sensitive to $\Delta\rho$ since λ_w and σ much larger

Intuition from simple model

- Next, suppose $\mathrm{d}z = gz\mathrm{d}t$ if employed, 0 otherwise

$$
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\rho W(z) &= \omega(z) - \sigma\left(W(z) - U(z)\right) + zgW'(z) \\
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\end{aligned}$$

- Surplus: $S(z) = W(z) - U(z) + J(z)$

$$S(z) = \frac{z-b}{\tilde{\rho}} + \frac{\tilde{g}z}{(\tilde{\rho} - \tilde{g})\tilde{\rho}}$$

  - $\tilde{\rho} = \rho + \sigma + \frac{1}{2}\lambda_w$
  - $\tilde{g} = g\left(1 + \frac{\lambda_w}{2\rho}\right)$: sensitive to $\Delta\rho$

Many-Good Economy

Many-Good Economy

- Multi-sector economy
- Each island produces tradable and nontradable goods
- Labor cannot move across islands but can switch sectors
- Study response to island-specific shocks
  - evaluate model against Mian and Sufi (2013) evidence
- Firms owned by consumers on all islands

Preferences

Household on island s:

$$\sum_{t=0}^{\infty} (\beta\phi)^t \, u\left(c_t\left(s\right)\right)$$

Consumption is an aggregate of tradeables (m) and non-tradables (n):

$$c_t\left(s\right) = \left[\tau^{\frac{1}{\sigma}} \left(c_t^n\left(s\right)\right)^{\frac{\mu-1}{\mu}} + (1-\tau)^{\frac{1}{\sigma}} \left(c_t^m\left(s\right)\right)^{\frac{\mu-1}{\mu}}\right]$$

Tradables imported from all other islands, s'

$$c_t^m\left(s\right) = \left(\int c_t^m\left(s, s'\right)^{\frac{\nu-1}{\nu}} \, ds'\right)^{\frac{\nu}{\nu-1}}$$

Prices

- Price of goods produced in s: $p_t^n(s)$ and $p_t^m(s)$

- Price of composite imported good in s

$$P_t^m(s) = \left(\int p_t^m(s')^{1-\nu} \, ds' \right)^{\frac{1}{1-\gamma}} = \bar{P}^m$$

- Aggregate price index in s

$$P_t(s) = \left[\tau \left(p_t^n(s) \right)^{1-\mu} + (1-\tau) \left(\bar{P}^m \right)^{1-\mu} \right]^{\frac{1}{1-\mu}}$$

Demand for goods

- Assume non-employed produce b units of composite good
  - Let $\bar{b}_t(s) = b(1 - e_t(s))$: total home production
  - Only $c_t(s) - \bar{b}_t(s)$ purchased on the market
- Demand for non-tradeables

$$c_t^n(s) = \tau \left(\frac{p_t^n(s)}{P_t(s)} \right)^{-\mu} \left(c_t(s) - \bar{b}_t(s) \right)$$

- Demand for variety s' tradeables:

$$c_t^m(s, s') = (1 - \tau) \left(\frac{p_t^m(s')}{\bar{P}^m} \right)^{-\nu} \left(\frac{\bar{P}^m}{P_t(s)} \right)^{-\mu} \left(c_t(s) - \bar{b}_t(s) \right)$$

Technology

- Two sectors: tradeables (x) and non-tradeables (n)
- $y = z$ in both sectors
- Matching technology:

$$M_t^x = B^x (u_t)^\eta (v_t^x)^{1-\eta} \qquad \text{and} \qquad M_t^n = B^n (u_t)^\eta (v_t^n)^{1-\eta}$$

$$\lambda_{w,t}^x = \frac{M_t^x}{u_t} = B^x \left(\frac{v_t^x}{u_t}\right)^{1-\eta} = B^x (\theta_t^x)^{1-\eta}$$

$$\lambda_{w,t}^n = \frac{M_t^n}{u_t} = B^n \left(\frac{v_t^n}{u_t}\right)^{1-\eta} = B^n (\theta_t^n)^{1-\eta}$$

Worker values

- Discount factor: $S_t = \left(\frac{c_{t+1}}{c_t}\right)^{-\alpha} \frac{P_t}{P_{t+1}}$

$$
\begin{aligned}
W_t^x(z) &= \omega_t^x(z) + \beta\phi S_t(1-\sigma)\int \max\left[W_{t+1}^x(h', z'), U_{t+1}(z')\right] dF_e(z'|z) \\
&\quad + \beta\phi S_t \sigma \int U_{t+1}(z')\, dF_e(z'|z)
\end{aligned}
$$

$$
\begin{aligned}
U_t(z) &= P_t b + \beta\phi S_t \lambda_{w,t}^x \int \max\left[W_{t+1}^x(1, z'), U_{t+1}(z')\right] dF_u(z'|z) + \\
&\quad \beta\phi S_t \lambda_{w,t}^n \int \max\left[W_{t+1}^n(1, z'), U_{t+1}(z')\right] dF_u(z'|z) + \\
&\quad + \beta\phi S_t\left(1 - \lambda_{w,t}^x - \lambda_{w,t}^n\right) \int U_{t+1}(z')\, dF_u(z'|z)
\end{aligned}
$$

Firm values

- No change in discount factor since owned by all islands

$$J_t^x(z) = p_t^x z - \omega_t^x(z) + \beta\phi(1-\sigma)\int \max\left[J_{t+1}^x(z'), 0\right] dF_e(z'|z)$$

$$J_t^n(z) = p_t^n z - \omega_t^n(z) + \beta\phi(1-\sigma)\int \max\left[J_{t+1}^n(z'), 0\right] dF_e(z'|z)$$

- Free entry:

$$\bar{P}^m \kappa^n = \beta\phi\lambda_{f,t}^n \int \max\left[J_{t+1}^n(z'), 0\right] dF_u(z'|z)\, d\tilde{n}_t^u(z)$$

$$\bar{P}^m \kappa^x = \beta\phi\lambda_{f,t}^x \int \max\left[J_{t+1}^x(z'), 0\right] dF_u(z'|z)\, d\tilde{n}_t^u(z)$$

Equilibrium prices

- Non-tradeables

$$\tau \left(\frac{p_t^n}{P_t} \right)^{-\mu} (c_t - b_t) = \int z dn_t^{e,n} (z)$$

- Tradeables ($\bar{\xi}$: vacancy posting costs + interest on debt)

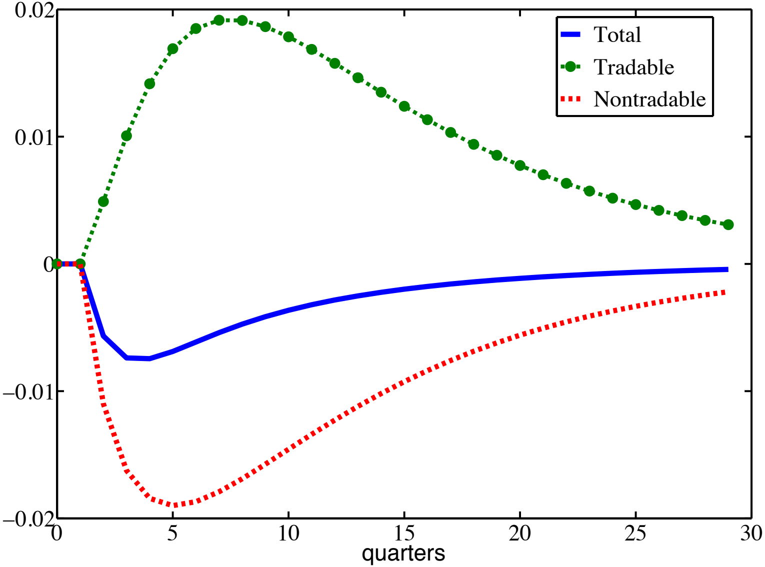
$$\left(\frac{p_t^x}{\bar{P}^m} \right)^{-\nu} \left[(1-\tau) \left(\frac{\bar{P}^m}{\bar{P}} \right)^{-\mu} \left(\bar{c} - \bar{b} \right) + \bar{\xi} \right] = \int z dn_t^{e,x} (z)$$

- Idea:
  - drop in c_t reduces p_t^n (more so when μ is low)
  - labor flows to x, reduces p_t^x (more so when ν is low)

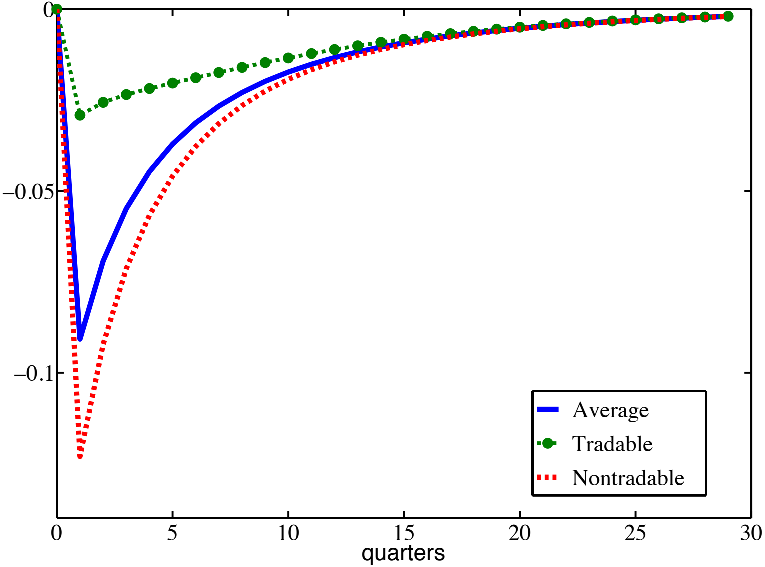
Additional parameters

- Preferences:
  - $\tau = 0.831$ (2/3 employment non-traded – Mian-Sufi)
  - $\mu = \nu = 1.5$ (Backus-Kehoe-Kydland)
- Choose B^x and B^n so that:
  - 80% employment-population
  - steady state $p^x = p^n$
- Choose κ_x s.t. $\theta^x = 1$, $\kappa_x / B_x = \kappa_n / B_n$
  - Implies $\theta^n = 1$ and $\omega^x(z) = \omega^n(z)$
- Steady state predictions = one-sector model

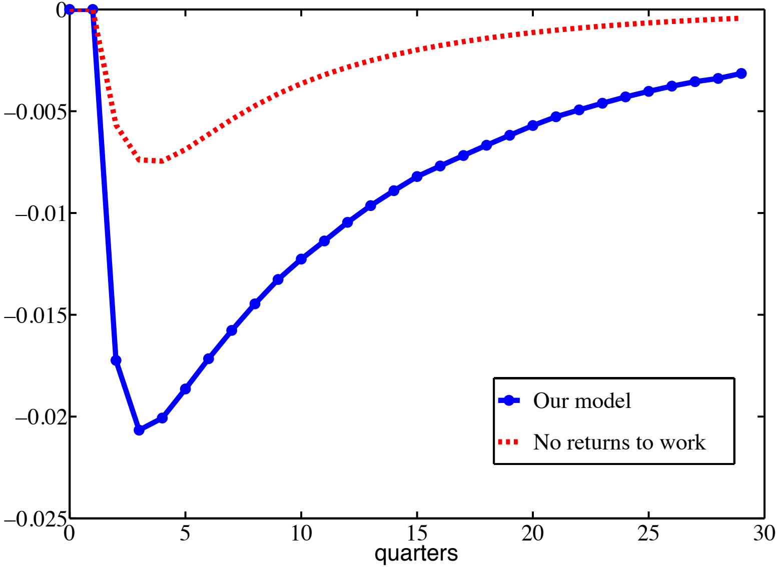
Employment responses absent returns to work



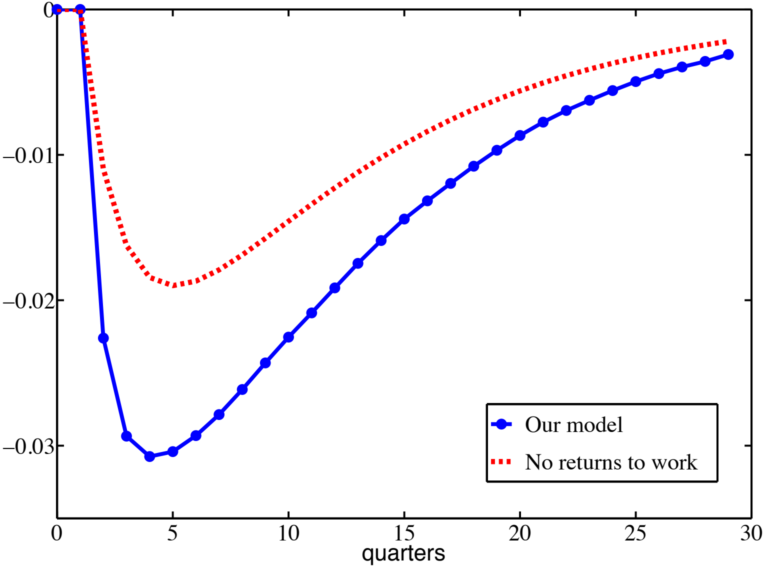
Wage responses absent returns to work



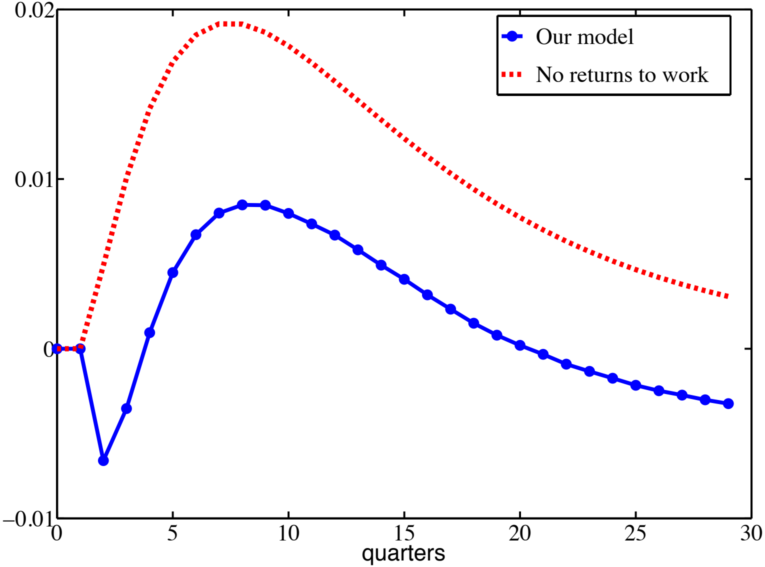
Our model: employment



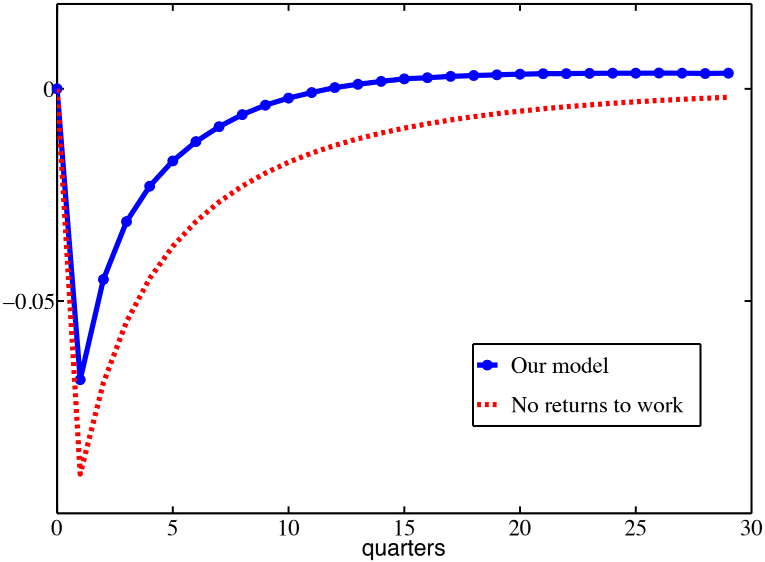
Our model: nontradable employment



Our model: tradable employment



Our model: wages



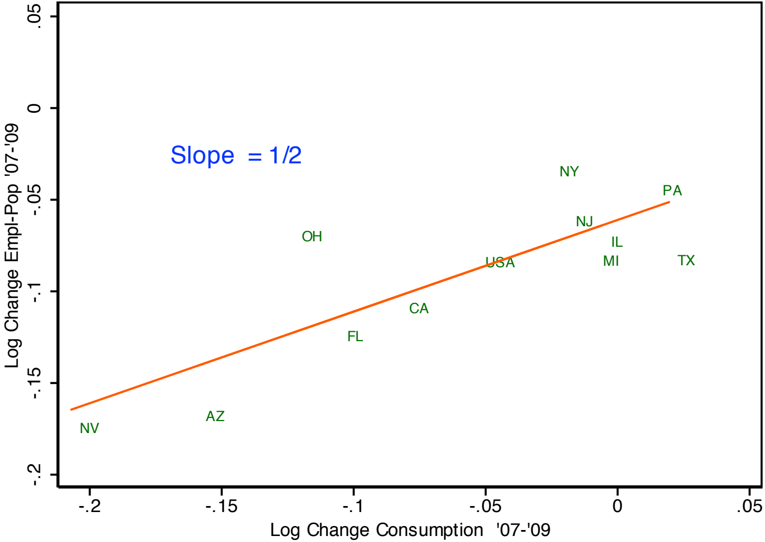
Experiment motivated by Mian-Sufi 2013

- Differentially tighten debt constraint on 20 islands
  - Island 1: consumption falls 1% after 2 years

    ...

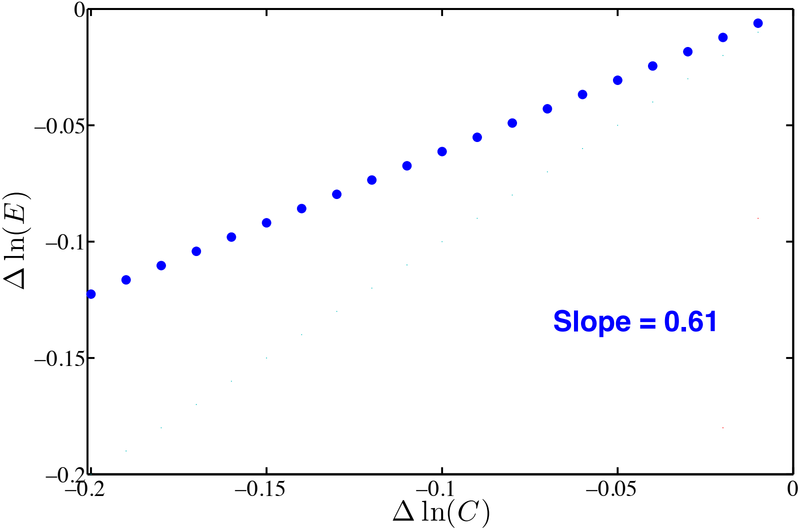
  - Island 20: consumption falls 20% after 2 years

Employment vs. consumption: data



source: Midrigan and Philippon (2011)

Employment vs. consumption: model



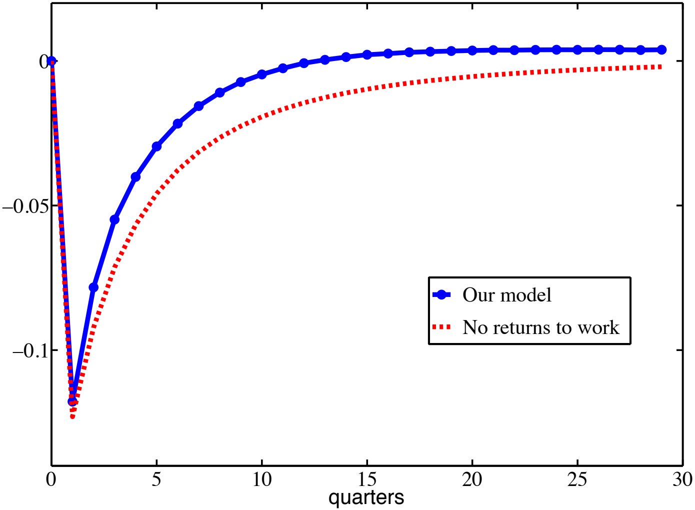
Summary

- DMP model with returns to work predicts:
  - employment sensitive to Δ HH debt constraints
  - as debt constraints reduce these returns
  - so reduce match surplus and employment
- Predictions consistent with Mian-Sufi evidence

Employment by sector, 2007-2009

source: Mian and Sufi (2013)

Our model: non-traded wages



Our model: traded wages